Journal of the Society of Arts.

FRIDAY, FEBRUARY 2, 1855.

SPECIAL PRIZES.

In addition to the General Premium List, the Council has determined to offer Special Prizes as follows:—

For two pounds of the best and finest FLAX THREAD, spun by machinery, suitable for lace-making. *Twenty-five pounds, or a Gold Medal of the same value.*

Note.—The Committee of the Normal Lace School of Ireland will be requested to report on the Specimens submitted.

For the best Essay on the Means of Preventing the NUISANCE of SMOKE arising from fires and furnaces; treating the subject practically, reviewing the various plans which have been put forth as remedies, with the experience of their success or failure, and the results of their adoption as to expense or economy, in erection and in working. The legislative measures necessary for the prevention of the nuisance, and the causes of the failure of the local acts for its suppression, should also form part of the Essay. *Twenty-five pounds, or a Gold Medal of the same value.*

Note.—The two foregoing prizes of £25 each, have been placed by Benjamin Oliviera, Esq., M.P., at the disposal of the Council for premiums during the year 1855.

For a COMPOSITION for the feeding rollers used in printing paper-hangings by cylinder machinery, similar in consistency and action to those used in letter-press printing, but adapted for working in water-colours. *The Society's Medal and five pounds.*

Note.—This premium has been placed at the disposal of the Council by S. M. Hubert, Esq.

For a "School" MICROSCOPE, to be sold to the public at a price not exceeding 10s. 6d. *The Society's Medal.*

To be a simple microscope, furnished with powers as low as those of a pocket-magnifier, for the purpose of observing flowers, insects, &c., without dissection. The lenses should range from two inches to one-eighth of an inch; the focal adjustment to be by rack-work, extending sufficiently above the stage to allow a thick object to be brought under the lowest power. It should be furnished with plyers, a concave mirror, and an illuminating lens, also a live box, or, instead of it, two or three glass cells of different depths, a few slips of common glass, and a few pieces of thin glass for covers.

Makers are requested to state at what additional price they will undertake to supply a doublet of 1-16th or 1-20th of an inch, applicable to any instrument as above described.

For a Teacher's or Student's MICROSCOPE, to be sold to the public at a price not exceeding £3 3s. *The Society's Medal.*

To be a compound Achromatic Microscope, with two eye-pieces and two object glasses, one magnifying 120 diameters with the lower eye-piece, the other magnifying 25 diameters with the lower eye-piece. It should be furnished with a diaphragm, having various-sized openings, mirror, side illuminator, live box, forceps stage and case.

In the event of the Medal being awarded, the Council is prepared to take 100 of the smaller and 50 of the larger Microscopes, at the trade discount.

The instruments for which the medals shall have been awarded will be retained by the Society as standards, and the successful competitors must enter into a guarantee to supply their Microscopes at the foregoing prices, and of equal quality with those retained, and to change them if not found satisfactory.

The Council, in all cases, expressly reserves the power of withholding the Premium or Medal altogether, should the Essays and articles sent in competition not be considered worthy of reward.

The Essays and articles intended for competition, must be delivered, addressed to the Secretary, at the Society's house, free of expense, on or before the 1st of May, 1855.

By order,
P. LE NEVE FOSTER,
Secretary.

Society's House, Adelphi, London,
31st Jan., 1855.

EXHIBITION OF INVENTIONS.

The Seventh Annual Exhibition of Inventions is fixed to open to the public on Monday, the 2nd of April next. These Exhibitions of the Society have now for so long formed part of its general action, and are so well known, that it is scarcely necessary to enlarge on the object and advantages of forming the collection. It may, however, be stated, that the importance of exhibitions of this character has long been pointed out, and the experience of the Great Exhibition afforded the unmistakeable testimony of fact in support of the arguments in favour of their utility. The Commissioners of Patents have already done much good by the publication of complete and excellent Indices; and the last volume just issued, giving references showing where all existing information in respect of patented inventions may be readily found, has done much to lighten the

labours of individuals, and cannot fail to assist the progress of Arts, Manufactures, and Commerce. The work of the Patent Office, however, is incomplete, until in connection with it a permanent Museum of Inventions be formed, where all may see what others have done and are doing.

The Society endeavours, in the meantime, to supply this want to some extent. Limited, however, as the Society's Exhibitions necessarily are, being dependent entirely on the voluntary assistance of the inventors themselves, they at least show the practicability of the idea, whilst their utility has been unquestioned. It is hoped that members and others will exert themselves to render the forthcoming Exhibition as complete as possible.

Articles for exhibition, consisting of specimens, models, and drawings of inventions, must be sent in not later than Monday, the 19th March, and applications for space by intending exhibitors should be made to the Secretary as early as possible.

NINTH ORDINARY MEETING.

WEDNESDAY, JANUARY, 31, 1855.

The Ninth Ordinary Meeting of the One Hundred and First Session, was held on Wednesday evening, the 31st inst., John Scott Russell, Esq., F.R.S., Vice President, in the chair.

The following Candidates were balloted for and duly elected ordinary members :—

Best, Hon. Robert Rainey.	Mein, Robert
Cockayne, Octavius.	Sloper, Joseph
Day, Thomas.	Thomas, Christopher James.
Frith, John Griffith.	White, Edward.
Fussell, Rev. James G.C.	Wilcocks, John.
Masters, James	

The Paper read was

THE CHALK STRATA CONSIDERED AS A SOURCE FOR THE SUPPLY OF WATER TO THE METROPOLIS.

BY SAMUEL COLLETT HOMERSHAM, M. INST. C.E.

The surface of the globe we inhabit is composed of land and water. The whole area of the surface of the globe contains 197 million square miles, of which land occupies 53 million square miles, and the ocean 144 million square miles. The ocean, therefore, occupies nearly three times as much of the surface of the globe as the land.

From this vast surface of salt water there is evaporated fresh or pure water, which rises and mixes with the air in the form of watery vapour. If a high current of such air meets a colder current, the invisible vapour is condensed into fog, which is seen from the earth as cloud, but if the air be blown inland, and especially over uplands and hills, the vapour is condensed into water by the cooling power of the ground, and falls down in the form of rain, hail, or snow.

Rain produced in this manner, after falling upon the land, imparting fertility to the soil, and supplying the wants of animal and vegetable bodies, for the most part either drains from off the ground into ditches, brooks, and rivulets, the waters of which, uniting together (from off large surfaces of country) form rivers, or else the greater portion of the rain goes down through the surface of the ground as fast as it falls, into underlying porous rocks, until it is arrested by impermeable matter, such as a stratum of clay, when it accumulates in the pores or crevices of the rocks, constituting subterranean sheets of water between the planes of stratification. These again accumulate until the pent up water can find a vent, as springs, at a lower level upon the surface of the earth, or can force its way by underground channels to the ocean.

Evaporation from the watery surface of the globe, in this way, is continually affording a supply of rain, and the rain deposited upon the land is constantly replenishing and feeding with water not only the springs, streams, and rivers visible upon the surface of the earth, but also large subterranean sheets of water.

When the ground is impermeable, the rain falling upon the surface in part enters into the composition of animal and vegetable bodies, and in part evaporates from the ground and mingles with the air in the form of vapour, while the remainder, when unobstructed, drains off the higher surfaces into the valleys, until it ultimately reaches a river and flows on to the sea.

In the hilly districts of Derbyshire, Lancashire, Middlesex, and other parts of Great Britain, it is very usual to collect water in large reservoirs, constructed by placing an embankment across a valley of an impermeable geological formation, such as millstone-grit, London clay, &c. These reservoirs are sometimes very capacious, and are used to collect large quantities of water for the use of canals, water-wheels, and for domestic consumption.

The following are examples of such reservoirs used for canals :—

The summit level of the Peak Forest Canal, which is situated near Whaley Bridge, in Derbyshire, is supplied with water by two such reservoirs, one called the Combs reservoir, and the other the Todd's Brook reservoir. The Combs reservoir, constructed in 1800, is capable of holding 54,289,000 cube feet; it is fed with water from floods that drain off a water-shed or drainage ground consisting of 2984 statute acres, or about 4⅔ square miles.

The Todd's Brook reservoir is capable of holding 47,412,270 cube feet; it is fed from the flood water draining off a water-shed of 4030 statute acres, or about 6¼ square miles.

The annual depth of rain falling in this locality varies from 33 inches in a dry year to 50 inches in a wet year. In a dry year it is found that the depth of rain flowing off the ground and not consumed by animal or vegetable bodies, or by evaporation, is as much as, or even more than, 24 inches in depth. Of this 24 inches, the greater bulk flows off the ground, after heavy rains, in a very short space of time. Thus, in the dry year of 1844, when only 33 inches in depth of rain fell during the year in the vicinity of the Todd's Brook reservoir, as much as 18 inches in depth of this quantity fell in less than thirty days, and as much as 15 inches in depth of the 24 inches that flowed off the ground, passed off in floods in 35 days; in fact, it is only when heavy floods flow off the drainage ground in larger volumes than the mills situated upon the stream below these reservoirs can use, that any water is impounded, so that these reservoirs depend for their supply of water upon floods, and so regularly do these floods take place, that in no one year since the construction of the Combs reservoir, (now more than fifty years ago) has this reservoir failed to collect very large quantities of water.

In the valley of the river Brent, situated in a north-westerly direction, and about 5¾ miles from Cumberland-gate, Hyde-park, is a large reservoir upon the London clay, similar to those before described, for collecting flood-water for the use of the Paddington Canal; and near Elstree, in Hertfordshire, is another reservoir, also situated on the London clay, and used for a similar purpose.

The following is an example of such a reservoir for the supply of mills :—

A few miles to the north of Bolton, in Lancashire, is situated a large reservoir capable of containing 100 million cube feet; it is fed with water from a drainage ground of about 2,000 acres, or a little more than 3 square miles. This reservoir collects and stores the water draining off the ground for the use of millowners situated below the reservoir.

The following is an example of such a reservoir for the supply of a large city:—

The Corporation of Manchester have nearly finished constructing five reservoirs, situated about 12 miles east of Manchester, in the valley of the river Etherow, that will contain, collectively, about 600 million cube feet of water. The top water of these reservoirs added together when full, would cover more than 400 statute acres of land, and they receive the rain water flowing off a watershed of about 18,000 statute acres, or 29 square miles. The Corporation of Manchester have bound themselves to send regularly down the brook-course from the reservoirs fed by this drainage ground about 17 million gallons per day for the use of the mills below, and after delivering this quantity, the Corporation calculate that at least as much more water as that sent down to the mills, will remain to be taken to Manchester for the use of the inhabitants.

These volumes of water are equal to about 31 inches in depth per annum flowing from off the drainage ground, and although the full amount calculated upon may not be realized in a dry year, yet large volumes of water during every year regularly flow off retentive soils in floods, and are collected in reservoirs for various purposes.

Numerous other illustrations might be given, to show that a very large proportion of the rain that falls upon retentive ground, is not consumed in supporting vegetation, or dried up by evaporation, or in feeding streams and rivers in dry weather, but that a large excess flows off the ground, so as to cause floods. These frequently occasion considerable damage.

Most persons will remember reading of, if they have not themselves seen, large quantities of land suddenly inundated with water from the overflowing of a river, or from the rain draining off high land; these inundations are common from rivers which carry off the rain falling upon retentive soils, such as clays, and from hills composed of mpervious rock.

In the *Times* newspaper of November 16, 1852, a description of several heavy floods will be found in various parts of the country. The following is extracted:—

"EXTENSIVE DAMAGE ON THE GREAT WESTERN.—During the whole of yesterday morning the traffic on this line was impeded, in consequence of a series of slips having occurred during the night between Paddington and Hanwell station. The early down-train was unable to get further than four miles down the line, when the engine-driver and guard discovered it to be flooded for several miles, in consequence of the water breaking through the sides of the cuttings; and it was further discovered that in about thirty or forty places extensive slips had taken place, principally on the up line. * * * During the whole distance between Hanwell to within four miles of Paddington, the line was under water, in some places more than two feet deep. In many parts the sides of the cuttings were washed completely over the line, and gangs of men, as we passed, were engaged in removing the debris. The train which should have arrived at Paddington by ten o'clock did not reach until half-past one, and the express shortly after. Many thousands of acres on each side of the line were covered with water."

"EGHAM, SURREY, Nov. 15, 1852.—The Thames here has overflowed its banks to an almost unprecedented extent, laying immense tracks of highly-cultivated land under water. All traffic on it is stopped, the towing-path being no longer discernable. The view from Cooper's-hill, Englefield-green, presents to the eye one vast watery plain, and, though novel, causes regret at the amount of injury done. At the foot is the celebrated Runnymede, a plain of about 160 acres, covered with water to the depth of from three to four feet, having the appearance of a lake, and on which numerous boats may be seen gliding along."

These floods were caused by a large quantity of rain falling in a short space of time. The average depth of rain that falls at Greenwich in a year amounts to about 24 inches. If this proportion of rain fell in equal depth during every day in the year, only 1-15th of an inch would fall on each day. But, as we all know, for many days and even weeks together it frequently happens that not a drop of rain falls, and at another time it rains for many days in succession, during which period the depth of rain that reaches the ground is very inconsiderable. At other times a great depth of rain falls in a very short space of time; thus on the 14th of July, 1853, at Lewisham, Kent, $2\frac{8}{10}$ inches fell in 17 hours; on the 28th of July, 1853, at Greenwich, $1\frac{3}{10}$ inch fell, of which $\frac{1}{4}$ of an inch fell in 20 minutes; on the 20th of August, 1853, $\frac{1}{4}$ of an inch fell in five minutes, and on the 22nd $\frac{73}{100}$ inch fell in ten hours; on the 9th of June, 1852, at Greenwich $1\frac{4}{10}$ inches fell, and on the 10th 1 inch fell, equal to $2\frac{4}{10}$ inches in about 40 hours; on the 25th of July, 1852, at Greenwich 2 inches fell, of which 1 inch fell within 15 minutes, and $\frac{1}{2}$ an inch fell in a quarter of an hour at another time in the day; on the 15th of August, 1852, at Greenwich $1\frac{3}{10}$ of an inch fell; on the 4th of October, 1852, at Greenwich 1 inch fell, from nine a.m. to nine p.m.; on the 23rd and 24th of July, 1851, at Lewisham $1\frac{25}{100}$ inch fell; on the 28th of August, 1851, at Lewisham, $1\frac{1}{2}$ inches fell in the night. These observations are recorded by Mr. Glashier, F.R.S., secretary to the British Meteorological Society, in his Quarterly Reports on the Meteorology of England and Scotland. All these are instances that occurred in a district where such falls are less in amount and less frequent than among uplands and hills.

It is when these large depths of rain fall in so short a space of time, that the banks of rivers are overflowed, and the adjoining low ground is inundated with water, more especially when the soil is in a damp or wet state.

It is floods caused in this way that fill the large reservoirs I have described, for supplying canals, water-wheels, and towns.

Indeed, collecting water in these reservoirs may be compared to the plan of collecting water in a rain-butt for the supply of a household. When rain falls on the roof of a house, butts collect the water, and store it for use in dry weather. To ascertain how much water can be caught from the roof of a house in any one year, it is only necessary to know the area of the roof of the house, and the annual depth of rain falling upon the house, as these two quantities multiplied together would give the amount of water that might be collected, if sufficiently capacious butts or cisterns were provided.

It is on the same principle that the amount of water that can be collected in a reservoir from a large drainage ground is determined. The area of the land in square feet is multiplied by the annual depth of rain that falls in feet, and the result is the number of cubic feet of water that falls on the ground. Of course a portion of the rain that falls on ordinary ground goes to support vegetation, or is taken up by evaporation; the amount of the whole rain-fall thus used is not easily ascertained; but it varies considerably in different situations and on different soils. In Lancashire and Derbyshire it is found that from retentive land, well covered with grass, as much as two-thirds of the whole depth of the rain falling in a dry year flows off the ground. It is after heavy rains that the great bulk of the water collected in reservoirs flows off the ground. At such times nearly the whole quantity of rain that falls runs off the ground in floods, as I have ascertained by direct experiments on a large scale.

We thus see that a large proportion of the rain falling on a soil resting upon clay, or other impermeable material, flows off the ground in floods as fast as it falls; that another

portion drains through the ground slowly, so as to feed the rivers in dry weather; and that the remainder enters into the composition of animal or vegetable bodies, or is evaporated.

The rain that flows down the river courses in floods, and the water that runs down the rivers in dry weather, may be seen, their course traced by the eye and their quantity measured. When, however, rain falls on a soil resting upon a porous rock, such as chalk, the water that falls upon the ground after heavy rains sinks into the earth, and is not visible to the eye. Nevertheless, by attention, the direction that the rain-water takes, after it disappears from the surface of the ground, and the quantity of water that thus goes down into the earth may be ascertained.

The surface of the ground upon which London, or the district usually termed the metropolis, is built, varies in elevation from the mean level of the sea to about 200 feet above that level.

Geologically speaking, the metropolis is situated upon the London and the plastic clays, and these formations present an exposed area around London of between 2000 and 3000 square miles. At Stanmore, to the north-west of the metropolis, hills of London clay rise as high as 500 feet above Trinity datum, or the mean level of the sea, and at Shooter's-hill, to the south-east, hills of London clay rise to about 400 feet above the sea. These points of the London clay are the highest to the north and to the south of the metropolis.

If in the metropolis we sink a well, or bore down into the earth, the greatest known depth below the level of the sea of the London and the plastic clays combined, is at Pimlico, where they are found to extend 280 feet below this datum; the least depth is at Deptford and New Cross, where they are not more than 40 feet below the same datum. At other parts of the metropolis the depth of the clays below Trinity datum varies between these two extremes.

At Hampstead, the London clay, which is there capped with gravel, rises to an elevation of 440 feet above Trinity datum, and the London and plastic clays go down 158 feet below this datum, so that the London and the plastic clays at Hampstead have a total thickness of 600 feet.

Immediately below the London and plastic clay formations we come to the chalk. Beneath these formations, the chalk extends in every direction, and beyond them rises to the surface of the land at the distance of about 16 miles in a north westerly direction from London-bridge, and about 9 miles in a southerly direction.

The exposed chalk to the north and north-west of London is 16 miles in breadth, and rises in hills known as the Chiltern-ridge, the tops of which vary in level from 400 to 900 feet above the sea.

The exposed chalk to the south of London, is from 6 to 7 miles in breadth, and rises in hills known as the North Downs, the tops of which vary from 600 to 800 feet in elevation. The total area of country in the south-eastern portion of England, in connection with these hills, where the chalk rises to the surface, covered for the most part with only a porous soil, amounts to 5,000 square miles, and the total area of chalk in connection with these hills, that is covered with the London and the plastic clay, and the crag formations, amounts to 6,000 square miles. This area is bounded on the east by the German Ocean, and on the south by the English Channel.

London is usually, though I think not accurately, described as situated in the centre of a chalk basin. Taken, indeed, north and south, the chalk does lie in the form of a basin. Beneath London, the lowest part of the surface is 280 feet below the level of the sea. From this depth, the chalk rises towards the north till it attains an elevation of from 400 to 900 feet, and towards the south to an elevation of from 600 to 800 feet; but taken east and west, the chalk rises to the west to an elevation of 1000 feet, and to the east forms the bed of the river Thames and the sea. To the north-west-by-west of London, the river Thames breaks through the chalk hills, entering this formation at an elevation of about 140 feet above the sea, and then taking a circuitous route flows on through London and joins the sea in an easterly direction; so that, if there be a basin, it is a basin with a gap on its north-west-by-west side, and altogether wanting on its eastern side.

The Thames for about thirty miles from where it enters the chalk, flows towards London on this formation; it then passes on for about 40 miles over the London and the plastic clays, flowing through London on these formations; but, again, from below Woolwich flows on the chalk till it reaches the sea.

London is, therefore, surrounded by chalk hills on the north, on the south, and on the west, and is bounded by the German Ocean on the east.

A glance at the geological map on the wall, or the model on the table, will show more clearly the physical conformation and the geological position of the country surrounding the metropolis. For our present purpose we must bear in mind that the metropolis is built on the London and the plastic clay formations, that these formations rest upon the chalk, the chalk again resting upon the lower green sand and gault, which is a stiff, blue clay, impermeable to water.

The London clay formation will need little description; it is a blue clay, very apt to run when wet; at places it is capped with gravel.

The plastic clay, which is next above the chalk, is composed of sand of various colours, pebbly gravel, and bluish clay; the exposed area of the plastic clay is small compared with the London clay, and for our present purpose these two formations may be considered as one.

The chalk formation is usually divided by geologists into three divisions; the 1st or uppermost division being the soft white chalk with flints; the 2nd division being the hard white chalk without flints; and the 3rd or lowermost division being the chalk marl.

The united thickness of these divisions of the chalk is from 600 to 1,000 feet. The chalk is a stratified formation, the planes of stratification being generally well marked, although at places they are somewhat obscure. The planes of stratification in the upper chalk, however, may generally be determined by the alternating layers of flints, which run in the same direction as those planes, and which are usually from two to four feet distant from each other, and from three to six inches in thickness.

The planes of stratification in the chalk are usually parallel, and vary in the distance apart, from a few inches to a few feet. Where a large extent of chalk is exposed, as in the cliffs by the sea side near Ramsgate and other places, the strata may be seen, as well as numerous fissures or joints usually at right angles to the planes of stratification; some fissures, however, are at right angles to the horizon, others diagonal. These fissures, crossing in various directions, divide the entire mass into irregular portions.

The upper green-sand, which lies immediately below the chalk and next above the gault, varies from 30 to 100 feet in thickness, while the gault, or blue marl, varies from 10 to 150 feet in thickness.

The gault extends, with few known exceptions, in every direction beneath the chalk, and dips conformably with it from the country north to the south of London, and from the country south to the north of London. The elevation of the surface of the gault to the north-west of London, where the Thames crosses this formation, is 150 feet; proceeding northward, near Aylesbury, it is 270 feet; near Dunstable, 250 feet; and near Biggleswade, 140 feet, all above the mean level of the sea. To the south of London the elevation of the gault exposed at the surface of the country varies in elevation from about 150 to 250 feet above the same datum.

Chalk is a marine formation, not crystalline; it is composed almost wholly of pure carbonate of lime. Dr. Mantell says that "a microscopical analysis shows it to be a mere aggregation of shells and corals, so minute that

upwards of a million are contained in a cubic inch of chalk; the amorphous particles appear to be the detritus of similar structures. These organisms, for the most part, are calcareous shields and chambered shells of the animalcules, termed foraminifera, which swarm in inconceivable numbers in our present seas, and are daily and hourly contributing to the amount of sediment now forming in the bed of the ocean."

In landscape the chalk formation, when it is close or very near to the surface of the country, is remarkable for its smooth and undulating outline, forming large basins, and rising into high hills and downs, which are, for the most part, free from trees or hedgerows. No drains or watercourses are required or used to carry off the heaviest falls of rain. On the sides of the steepest hills the rain is absorbed as fast as it falls, and in this respect the chalk formation altogether differs from, and forms a remarkable contrast to, that portion of the country composed of London clay. Very large areas of hills absorb the rain as fast as it falls, so thoroughly that no stream, river, or surface spring is visible any where upon them.

On the Chiltern ridge, which is the name given to the chalk-hills to the north of London,—there is an entire district of more than 200 square miles of country without a stream, river, or surface-spring to be seen anywhere upon it, nor, without sinking a well to a considerable depth, sometimes as much as 260 feet, can water be procured.

Wherever chalk forms the surface of the country, streams and rivers are very scarce compared with almost any other geological formation, as will be seen from a reference to the following table, which gives the area in square miles of the different geological formations in the south-eastern portion of England, the length of river courses in miles upon each separate formation, and the length of stream or river course per square mile:—

Geological Formation.	Area.*	Absolute Length of Streams and River Courses.	Comparative Length of Streams and River Courses, per SquareMile
	Sq. Miles.	Miles.	Yards.
Crag	2056	1996	1709
Bagshot Sand	168	165	1729
London and Plastic Clay .	4071	4741	2057
Chalk & Upper Green-Sand	5353	2391	782
Wealden Clay	763	905	2087
Hastings Sand.	577	700	2135

Thus it is seen that there are only 782 yards of river course, per square mile, upon the chalk formation, while there are 2,057 yards of river course per square mile upon the London clay, or nearly three times as much, besides which there are great lengths of ditches and drains upon the clay formation, altogether absent upon the chalk.

Not only are the river courses much less in length upon the chalk formation, but they are also much smaller in size.

I have here drawings, made to the same scale, of nine pairs of bridges crossing rivers and streams.

One bridge, of each set of drawings, crosses or spans a river course, where the country draining into the river above the bridge has chalk at or near the surface; the other bridge of each set crosses a river that has, as nearly as could be found, the same area or number of square miles draining into the river above the bridge where the country is composed of clay.

The first example commences with a bridge having 11½ square miles of drainage, and the ninth, or last example, having 100 square miles of drainage, the other examples having intermediate quantities of drainage ground.

An examination of the drawings, or of the following table, shows (see Table, page 172) that the water-way for a bridge per square mile of chalk drainage is only from one-fifth to one-tenth the relative area or size of the water-way of a bridge with a clay drainage. Besides, in every case it was clearly ascertained that the water-ways for the clay drainage-grounds had been frequently choked with water after heavy rains, while the water-ways for the chalk drainage were always more than ample in size. Before a flood of any magnitude can occur in a chalk country there must be first a soaking rain, immediately followed by a hard frost; then a heavy fall of snow, and all this succeeded by a sudden thaw, acting on the snow. Such a concurrence of circumstances has happened, but it is of rare occurrence.

Here, then, we have ample and positive proof that the rain, falling on a chalk country, does not flow off the land in floods, as it does from a clay country.

Again, as to evaporation, the surface of the ground does not lose so much of the rain that falls in a chalk country as in a clay country. After the heaviest rain, the surface in a chalk country is dried in a few hours by the descent of the rain into the ground, away from the influence of the sun and wind; while in a clay country, the ground after rain is wet at the surface for many days in succession. Accordingly it is matter of notoriety, that the air in a chalk country is drier than in a clay country. Of the rain falling on chalk, then, much less is lost by evaporation.

Notwithstanding that the heavy rains never run off the surface of a chalk country to anything like the extent they do in a clay country, yet the yield of a stream fed from the drainage of any extensive area of chalk country is never larger in volume in dry seasons than the yield of a stream fed from a similar area of clay country, so that there is no compensation from a larger yield in dry weather.

On clay it is found, as before stated, that nearly two-thirds of the water that drains off the ground, runs off after heavy rains in floods, and that large reservoirs are frequently constructed to impound such floods and to store them for use in dry weather.

On the chalk formation such reservoirs are never constructed, for the very good reason that there are no floods to impound. The chalk itself constitutes a natural reservoir.

In illustrating this peculiarity of the chalk formation, when it is near the surface of the ground, the description, before given, is a general one. When speaking of 5000 square miles of country, or 3,200,000 acres of land, it must be understood that there are places where the chalk is covered with gravel; other places where the chalk is covered with sand; other places where the chalk is covered with clay, more or less thick; and almost everywhere the chalk is covered with soil of a greater or less thickness, besides vegetation at least for a great part of the year. In many parts of Hertfordshire, especially to the north of London, and in other places, extensive tracts of clay lie upon the chalk; rain, however, falling on these patches of clay, is now usually drained into the chalk by means of wells sunk through the clay and continued for a short distance into the chalk. These wells are then filled up with flints and stones and the surface drains of all land lying above the wells are carried into the wells. The drainage water, upon reaching the chalk, soaks away as fast as it touches it. These wells are usually termed dumb wells, and of late years have been so extensively made use of, that the amount of water running down the rivers on the chalk formation, has been considerably lessened, and the supply of water to the mass of the chalk increased.

As a whole, however, the chalk formation may be said to absorb almost all the rain that falls upon its surface, giving out again but little to support vegetation, as is made manifest by the scanty herbage on chalk downs.

* The superficial contents, &c., are taken from the Ordnance Map of 1 inch to the mile, and are exclusive of the Isle of Wight and a circle round London of 7¼ miles diameter.

TABLE shewing the area of the water-way of nine pairs of bridges. One bridge of each pair has a drainage-ground of the chalk formation, and the other, as nearly as could be found, a similar area of drainage-ground of the London-clay formation.

SITUATION OF BRIDGES.	Area of Water Shed or Drainage Ground.	Geological Formation.	Area of Waterway	OBSERVATIONS.
	Sq. Miles.		Square Ft.	
Mountneysing, Essex, River Roding	11½	London clay.	191	Often filled with flood water.
Kimpton Hoo Park, Herts, River Mimram ...	12¾	Chalk.	19	Never full of water.
Chipping Ongar, Essex, River Roding...........	21	London clay.	279	Often filled with flood water.
Welwyn, Herts, River Mimram	23¼	Chalk.	26½	Never full of water.
Colney Street, Herts, River Colne	39¼	London clay } 28½ Chalk } 10¾	267½	Often filled with flood water.
St. Alban's, Herts, River Ver........................	38	Chalk.	48½	Never two-thirds filled with water.
Near Margaretting, Essex, River Chelmer	42½	London clay.	350	Bed of river and piers show signs of heavy floods.
Park Street, Herts, River Ver	43	Chalk.	65	Rarely half-filled with water, even after heavy falls of snow.
Writtle, Essex, River Chelmer	49	London clay.	358	Frequently filled with water after floods.
Chalfont, St. Peter's, Bucks, River Misbourne.	49½	Chalk.	40	Never half-filled with water.
Coggleshall, Essex, River Blackwater	58	London clay } 48 Chalk } 10	179½	Often filled with flood water.
Denham, Bucks, River Misbourne	56	Chalk.	19	Never filled.
Kelvedon, Essex, River Blackwater	62	London clay } 52 Chalk } 10	390	Often filled with flood water.
Stanborough, Herts, River Lea	61	Chalk.	50	Never three-fourths filled with water.
Stappleford Abbots, Essex, River Roding	79½	London clay } 73½ Chalk } 6	495	The water-way not sufficiently large to carry off ordinary floods. The country above is often flooded for miles.
Hertford, Herts, River Bean	72	Chalk partially covered with impermeable drift.	173	Rarely half-filled with water.
Loughton, Essex, River Roding......................	99¼	London clay.	693	Often filled with flood water.
Winchester, Hants, River Itchen	102	Chalk.	187	Never two-thirds filled with water.

A portion, however, of the rain absorbed re-appears at the bottoms or the sides of some valleys as springs, which, together with a portion of the rain-fall drains off the soil lying on the surface of the chalk, and forms rivers, which are generally insignificant compared with the extent or area of country drained by them.

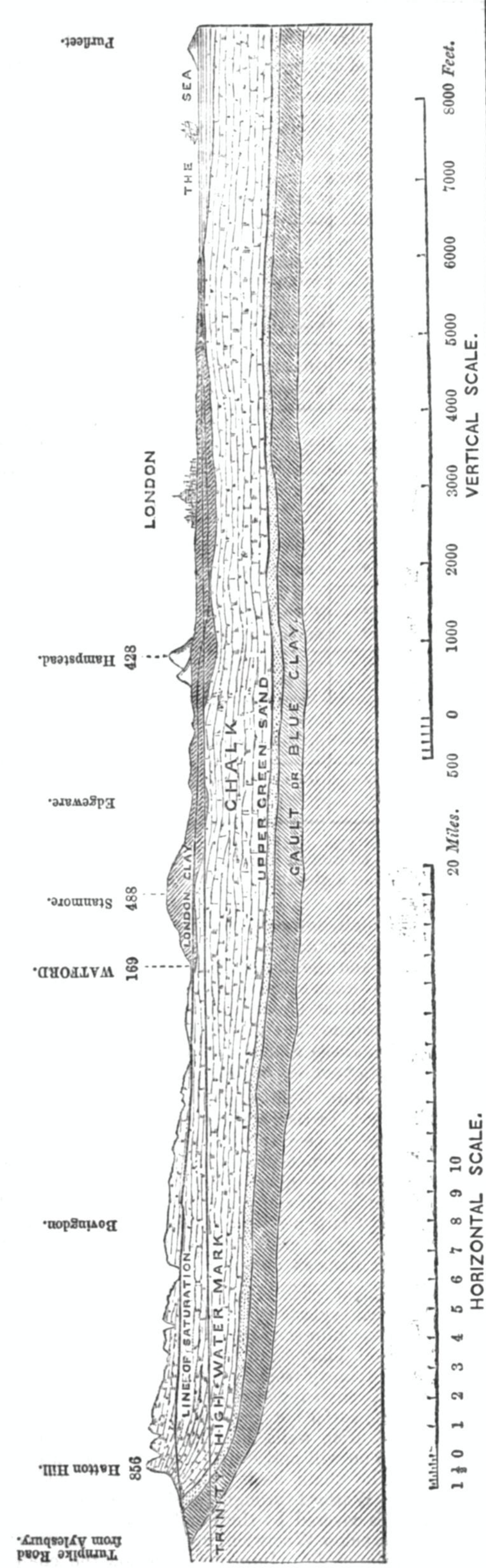
Experiments on a large scale have been made of the quantity of water yielded by the river Lee at Field's Weir, the junction of the river Stort. The area of country draining to this point amounts to 444 square miles, and includes the Lee proper and the Mimram, the Beane, the Rib, the Ash, the Stort, and the surface springs between Ware and Field's Weir; although out of the 444 square miles of drainage ground 50 square miles are covered with the London and the plastic clays; and though the drainage ground of the most easterly streams is covered with extensive patches of clay not yet fully drained into the chalk, it was found that in 1851, out of a rain-fall of 23 inches in depth, only six inches, including the produce of the floods from the clay land, together with the springs, flowed off the ground.

There can be no doubt that, even in that year, which was comparatively a dry year, at least ten inches in depth of the rain went down through the surface into the body of the chalk, for, allowing one inch of the six inches that was measured to be the produce of the floods from the clay land, five inches in depth only would flow off the chalk drainage ground; therefore, assuming as much as eight inches in depth of the rain-fall to be taken up by the vegetation and by evaporation, which is a liberal allowance, only 13 inches in depth of the rain-fall would be accounted for in this locality, the rest of the 23 inches, that is, 10 inches, having sunk in the ground. Now it must be remembered that there are very large areas of chalk country of a basin-like form where not a drop of water runs off the surface, either in rivers or springs, so that over the entire chalk area, there can be no doubt, that a larger average quantity than a depth of 10 inches was absorbed even in the year 1851.

The rain-fall, however, over the whole of the chalk formation, and especially about the North Downs to the south of London, and the Chiltern ridge to the north of London, will on an average of years be more than 23 inches. The mean rain-fall at Greenwich is as much as 24 inches in depth per annum, but from the greater elevation of the chalk hills, at least 26 inches in depth must fall, on an average of years, upon the chalk formation.

After making a liberal deduction from the rain-fall for the water carried off from the chalk by the rivers and by the surface springs, and for the amount that enters into the composition of animal and vegetable bodies, and that which is taken up by evaporation, it is certain that on an average of years, at least a foot in depth of the rain that falls per year, sinks through the surface of the land into the great body of the chalk, and remains there till it finds an outlet.

The woodcut, page 173, shows the section of the country from near Aylesbury, 36 miles north-west of London, through the Chiltern-ridge, Watford, Stanmore, London, and the river Thames, to the sea. The form of the surface of the country from London along the line of section is accurately shown, and the thickness of the London clay between the surface of the land and the chalk, has been ascertained from wells sunk along or near the line of section. You will notice that from the Chiltern-ridge to Watford, the chalk itself appears near the surface, and that from Watford through London to below Woolwich, the chalk is covered by the London and the plastic clays, while from below Woolwich, the river Thames runs to the sea upon the chalk. Immediately below the chalk is an impermeable stratum of gault, that is, blue clay. This



SECTION THROUGH THE CHILTERN RIDGE, WATFORD, STANMORE, LONDON, AND THE RIVER THAMES TO THE SEA.

impermeable stratum rises to the north so high, as almost entirely to prevent any water flowing northwards.

The highest portion of the Chiltern-ridge shown on the section is 886 feet above the level of the sea, and the level of the surface of the chalk at Watford is 169 feet above the same datum, as shown by the figures on the section. From Watford the surface of the chalk undulates, and gets lower as it approaches London, till it is at places 276 feet below the sea, when it rises again towards Woolwich, forming the bed of the Thames and of the sea, rising up in hills to the north of the Thames at Gray's Thurrock, and to the south of the Thames at Gravesend. The undulations of the upper surface of the chalk from Watford under London to Woolwich, are filled up with London clay, which at many places, as at Stanmore and at Hampstead, is of considerable thickness.

How the water flows through the chalk formation can be easily explained by the section. The rain falling upon the pervious soil that overlies the almost bare chalk from Watford to the Chiltern-ridge, immediately sinks into the chalk, which near the surface is knobly or broken in small pieces for some feet in depth before the stratified chalk is reached. The heaviest rain is absorbed as fast as it falls, the pores of the chalk acting in the same way as the reservoirs that are used in Derbyshire, Lancashire, and Middlesex, to store flood-water. Chalk is extremely porous, one-third of the bulk of the upper chalk consisting of pores; thus every yard of three feet in depth of the upper chalk, when dry, can receive into its pores a rain-fall of one foot in depth before it is saturated; that is to say, a piece of dry chalk a yard square and a yard thick would absorb, or take into its pores, a yard square of water by ⅓ of a yard or a foot thick. As the heaviest falls of rain upon the chalk rarely exceed a quarter of a foot in depth over the surface in 12 hours, the facility with which chalk will imbibe the rain as it falls will be easily understood.

If upon the top of an upright pillar of dry chalk, a yard square and 30 yards high, were poured a quantity of water, the water would be gradually disseminated throughout the whole mass of the chalk; but the utmost quantity of water this mass of chalk could take into its pores, would be a quantity equal to one yard square and 30 feet deep, as this amount of water would fill all the pores in the chalk. If, however, the water was continued to be poured upon the top of the chalk, then the water as it descended through the upper portion of the chalk would, by its gravity, in time, fill the pores of the lower part of the chalk, while yet the upper portion would remain comparatively dry; and, as the water slowly percolated through from above, the lower mass of chalk would, when saturated, allow the water to drain hrough, and flow away from it altogether. The percolaion of the water through the mass of the chalk hills takes place in a similar manner.

In those hills, however, the percolation is facilitated by the varying pressure of the atmosphere. When the barometer is low, the air in the chalk, being expanded, is given out of its fissures and pores, and when the barometer rises, the air, being condensed, enters its pores and carries with it any water that may lie between the fissures of the planes of stratification in the chalk. Thus every change of the barometer puts in motion the water in the pores of the chalk, and slowly but surely assists the rain from above in reaching the lowermost beds of chalk, at the same time that it oxidises any organic matter that was taken up by the rain in percolating through the soil at the surface, as will be more particularly alluded to hereafter.

The capillary attraction due to the small pores of the chalk would keep some water disseminated through the whole body of it, but mere capillary attraction would leave some spaces unoccupied with water. If a quantity of water were continued to be poured on the top of the supposed pillar of chalk, it would gradually descend through the upper portion, and in its descent force out

from the lower mass of the chalk some of the water before contained in its pores. Thus the water that would run out at the bottom of the chalk, would not be the identical water immediately before poured upon the top of the chalk; just as would happen if a tube or pipe, one mile long, were laid horizontally, with its two ends turned up, one a little higher than the other; if the whole pipe were filled with water, and a gallon of water were poured in at the higher end, although a gallon would run out of the other end, yet it would not be the same water.

In the same manner the rain that falls and percolates through the surface or top stratum of the chalk hills takes many years to reach the lowermost stratum. Taking the chalk formation to be from 200 to 300 yards thick, and the annual depth of rain percolating through its surface at one foot in depth, it is pretty certain that generation after generation will pass away before the rain that fell during the last year and went down into the chalk, will reach the lowermost stratum.

Turning to the section, page 175, you will notice that the surface of the chalk from the Chiltern ridge slopes towards London and the sea, and that the bed of gault, or blue clay, below the chalk, inclines in the same direction. This bed of gault, and the impervious beds of the lowest chalk, prevent the water from escaping below, so that the whole mass of the lower portion of the chalk becomes saturated. You may observe that the great bulk of the chalk lies below the level of the sea, and even extends far under the sea. There can be no doubt that when the chalk-hills were thrown up to their present elevation, the pores of the whole mass of the chalk were filled with sea-water. The incessant rains of countless years having, however, descended through the chalk, the sea-water has been displaced by the rain-water, the salts originally contained in the chalk have been washed out of it, and the chalk has become saturated with fresh water, not only up to the level of the sea, but as high above the sea as is shown by the line of saturation upon the section. This line shows the height from above the gault that the chalk is saturated with water, as ascertained in May, 1852, from wells that are situated along or near to the line of section. When a well is sunk into the chalk, for some distance from the surface, the chalk is usually found comparatively dry, but upon sinking deep enough, the chalk is at last found saturated with water, which flows out of the chalk so easily, that the bottom of the well is soon filled with water and the workmen are unable to proceed with sinking the well any deeper. For ordinary purposes, a well sunk as deep as the well-sinkers can work in, suffices to yield water for the supply of a large household. When a larger quantity of water is wanted, either a bore hole is sunk through the chalk by means of rods, or else pumps are used to pump water out of the well, to enable the workmen to go deeper into the chalk, or to make small tunnels below the line of saturation. Near the Chiltern ridge some wells are sunk through the chalk from 220 to 250 feet from the surface before the line of saturation is arrived at.

In a straight line 15½ miles north-west of Watford, the chalk is saturated with water to a height of 470 feet above the sea; at Watford the height is only 169 feet, and towards the sea coast it is about the level of high-water, and even varies with the height of the tide; so from the Chiltern ridge through the chalk towards the coast there exists a considerable subterranean sea of water, not level at the surface, like a lake, but declining gradually, being abrupt only where diverted by faults or cavities.

In a straight line about 16 miles south of London-bridge, the line of saturation in the chalk in the North Downs, is also several hundred feet above the level of the sea, and the line of saturation gradually lowers, but in a southerly or south-easterly direction, towards the Thames and the sea coast.

When the surface of the chalk is at a lower level than the sea, and covered, as below London, with impermeable clay, then the surface of the sheet of water is kept down, as it cannot rise through solid clay, but if the chalk have a porous covering, such as gravel or sand, the water will rise so as to maintain the inclination of the surface of the water unbroken, and if a hole be sunk through the clay to the chalk, water will rise from the chalk into the hole, to the same level as it would have stood in the chalk.

This is the condition of the chalk strata at and around London, as determined from careful surveys and levels, and you will now at once perceive how the rain falling on the hills to the north and south of London disappears and is not seen, as it is on clays and clays capped with gravel, in the form of rivers and surface-springs. The rain sinks into the porous chalk at the surface of the ground as fast as it falls; and descending by its gravity, displaces the water in the stratum of chalk immediately below it; this yields the water it before contained to the next descending stratum. Each descending stratum in succession, thus receiving water on its upper surface, and giving water out at its lower surface, until the line of saturation in the chalk is reached.

The rain thus maintains the line of saturation in the chalk hills to such a height or inclination as will suffice to carry the water away through the chalk to the lowest point where it can find a vent and can escape. This is the level of the water in the sea, the sea being in immediate connection with the chalk itself, as at Wells, Erith, Northfleet, Deal, St. Margarets, Dover, Brighton, Weymouth, and other parts along the coast, where the issue of large bodies of fresh water from the chalk direct into the sea can be distinctly traced.

As it frequently happens that a great deal of rain falls in one part of the year, and very little at another, and also that a much larger quantity of rain falls in one year than in another year, so does the line of saturation rise or fall in the chalk hills furthest from the sea. At one season of the year this level is frequently from thirty to forty feet higher than at another, and in one year there is also a different level to another year, at one place different to another place. High up at Dunstable the variation of the level of the water in the wells is about thirty feet annually, the water constantly rising during one portion of the year and falling during another; while lower down, at Watford, the variation is very little in the shallow wells, and is not perceptible in deep borings. At Uxbridge many borings sunk into the chalk constantly overflow above the surface of the ground, and have done so for a great many years past without any variation or diminution in the quantity yielded.

The direction in which the subterranean currents of water most freely flow to the ocean, of course, depends upon the inclination of the planes of stratification, the size of the interstices between them, and the positions in which the more fractured or more permeable chalk may happen to lie. The subterranean water will take the course that offers the least obstruction to its flow, and local investigations are required to ascertain the direction of the greatest flow in any particular place.

The capacity of chalk for holding water varies considerably. Thus a cubic foot of chalk at Boxmoor, weighing, when dry, 82¼ lbs., will contain, when saturated, 26¼ lbs. of water, or more than $2\frac{6}{10}$ths of a gallon; while a cubic foot of chalk, when dry, procured at Kentish-town, from below 370 feet of London clay, weighing when dry 106lbs., will contain, when saturated with water, only 19½ lbs., or $1\frac{9}{10}$ of a gallon. And a cubic foot of chalk-rock, frequently encountered in sinking wells and borings in the chalk, which, when dry, weighs 137 lbs. 5¾ ozs., contains, when saturated with water, only 9 lbs. 10½ozs. of water, or little less than a gallon. This is more fully shewn in the table, page 175:—

It is this difference in the capacity and permeability of different strata of chalk, combined with the varying inclination of the strata and the intervention of faults, that produces surface-springs in some

TABLE SHEWING THE CAPACITY OF DIFFERENT SPECIMENS OF CHALK FOR HOLDING WATER.

LOCALITY AND DEPTH FROM THE SURFACE OF THE GROUND AT WHICH THE SPECIMENS OF CHALK WERE OBTAINED.	Weight of the chalk per cube foot when thoroughly dry.		Weight of the chalk per cube foot when saturated with water.		Weight of water in a cube foot of saturated chalk.		Measure of water in a cube foot of saturated chalk.	Specific gravity of the chalk irrespective of its porosity; *i.e.* supposing the chalk to be so compressed as to obliterate its pores or cavities.
	lbs.	oz.	lbs.	oz.	lbs.	oz.	Gallons.	
Boxmoor, Herts, 5 feet deep from a cutting	88	9	114	13¾	26	4¾	2· 63	2·460
Boxmoor, Herts, 12 feet deep from a cutting	85	6	111	13¾	26	8	2·649	2·383
Boxmoor, Herts, 30 feet deep from a cutting	90	5	116	13½	26	8½	2·655	2·524
Abbot's Langley, Herts, 5 feet deep from a cutting	110	8	130	6	19	14	1·988	2·601
Abbot's Langley, Herts, 40 feet deep from a cutting	105	11	127	6	21	11	2·169	2·601
St. Alban's, Herts, 29 feet deep, well that supplies the town	89	7	117	10	28	3	2·823	2·620
St. Alban's, Herts, 146 feet deep, well that supplies the town	94	1¾	120	9½	26	8	2·649	2·629
Bushey, Herts, 4 feet deep, from lime kilns	106	15	128	2	21	3	2·119	2·600
Bushey, Herts, 51 feet deep, from lime kilns	104	6	126	13	22	6½	2·244	2·618
Bushey, Herts, 35 feet deep, well near lime kiln	118	13½	135	12¾	16	15¼	1·695	2·621
Loudwater Mill, Herts, chalk rock, frequently met with in boring	137	5¾	147	0¼	9	10½	0·966	2·609
Gravesend, Kent, 3 feet deep, well	88	1	116	1¾	28	0¾	2·804	2·568
Gravesend, Kent, 60 feet deep, well	93	10¾	119	1½	25	7¾	2·542	2·539
SPECIMENS OF CHALK PROCURED FROM BELOW LONDON CLAY—								
Hartsbourne, Bushey Heath, Middlesex, 400 feet deep, well, clay 230 feet deep above the chalk	142	14½	151	14	9	0	0·897	2·679
Kentish Town, Middlesex, 500 feet deep, clay, gravel, and sand, 270 feet deep above the chalk	106	2	125	10¾	19	8½	1·951	2·480
Kentish Town, Middlesex, 538 feet deep, Do. Do.	111	6	129	10	18	4	1·826	2·529
Kentish Town, Middlesex, 500 feet deep, Do. Do.	111	5	127	4	15	15	1·595	2·398

The experiments upon the different specimens of Chalk were made in 1851, by John Smith, M.D., then Assistant in the Chemical Laboratory and Fordyce Lecturer in Marischal College, Aberdeen, and now Professor of Chemistry and Experimental Physics in University College, Sydney.

places, and causes in others considerable currents of subterranean water in particular directions. The great weight of the London clay overlying the chalk situated below the metropolis appears to have condensed the chalk; at least it is very much less permeable to water than where the chalk is not so thickly covered with clay. This explains the notorious difficulty of procuring large volumes of water from the chalk under London, after sinking through the London clay, and makes more intelligible the fact, that the water procured from the chalk under many parts of the metropolis is quite different in quality from the water procured from the chalk where it is not covered by London clay; for instance, water from the well that supplies the fountains at Trafalgar-square, contains 70 grains of mineral or saline matter per gallon, 60 grains of which are common salt, potash, and soda; the water from the chalk at Watford contains only 23 grains of mineral matter per gallon, of which there is altogether less than two grains of salt, potash, and soda. It thus appears certain that the compactness of the chalk under London has always prevented sufficient water from the uplands passing through to wash out the salts originally contained in it. It has been said that the lowering of the levels of the water in some of the wells under London is caused from want of water in the great mass of the chalk hills beyond Watford, but as the present level of the water beneath London is artificially lowered by pumping in some wells to 60 or 70 feet below Trinity high-water mark, it would be as reasonable to say that the difficulty of brewers and others in procuring large quantities of water from deep wells sunk into the chalk under London, arises from their having already exhausted the sea, which is quite as near, and not less copious.

Many exaggerated statements have been made relating to the water of the wells sunk under the metropolis into the chalk. Most persons will have heard it stated in general terms that the level of the water in the wells beneath London has been steadily lowering for years past, and, no doubt, certain wells have lowered since they were first sunk, but upon investigation it will be found that the water in many wells—that at Orange-street, to supply the Trafalgar-square fountains, for instance—has never lowered at all *since the well was first sunk*, although larger and larger quantities of water have been pumped from it for the last 10 years.

At places extensive faults (or breaches) are found in the chalk, as, for instance, at Hemel Hempstead, to the north of London. These faults allow the water draining from the chalk hills to get direct down into the lower portions of the strata, and this water, so conducted, meeting with the readiest course through the interstices between the planes of stratification in the lower chalk, takes that course to the sea. The water-level in the chalk at these faults is frequently 250 to 260 feet above the sea, and when holes at a considerable distance towards the sea are bored down through the chalk so as to intercept the planes of stratification leading from these faults, large volumes of water may be intercepted on their passage to the sea, without the possibility of interfering with surface springs or streams. Indeed, if the level of the surface of the ground where a boring is made is low enough, and large fissures be met with in the chalk, overflowing springs may be and frequently are, thus produced. This may be seen exemplified close to Redbourne, in Hertfordshire, where five borings, only 12 inches diameter, sunk through the chalk for 270 feet in depth, overflow, and thus supply the head of the river Ver with 750,000 gallons per day, although the top of the bore hole where the water overflows is 281 feet above the level of the sea at high-water.

Within convenient reach of the metropolis northwards there are at least 1,200 square miles, and southward at least 200 square miles, of chalk hills, the greater portion of the water percolating through which could be easily collected for the supply of the metropolis.

Taking only a foot in depth per annum as the amount of water sinking into 1,400 square miles of chalk, this

would produce more than 660 million gallons per day for the supply of the metropolis.

Almost the whole of this vast amount of water now finds its way underground, silently and unseen, to the sea, without being of any service to man or beast, in town or country.

The judicious interception of the small fraction of this water that would be required for the supply of the metropolis, could no more injure or interfere with the existing wells, or the surface springs, streams, and rivers in the chalk districts, than the raising of a portion of the Thames at Teddington, could dry up the streams in the districts that feed this river.

A heavy shower of rain over the before-mentioned 1400 square miles of chalk country, such as brought down one inch in depth, which often falls in a few hours several times in a year, would produce 54 million gallons per day for every day in the year; this is more than the supply furnished to the metropolis by all the companies put together.

At the present time, the towns of Brighton, Gravesend, Ramsgate, Margate, Dover, Winchester, St. Albans, Woolwich, &c., are supplied with water derived from the chalk. The water is abundantly procured by sinking wells or making borings into the chalk.

Let us now examine the quality of the water.

The rain, when it falls upon the surface of the soil overlying the chalk, carries with it a portion of the manure put upon the land, the decaying plants, leaves, or other organic matter with which it comes in contact. A great part of the water, before reaching the line of saturation in the chalk, is held for a long time in the pores of the chalk by capillary attraction. Now, porous bodies, such as chalk or charcoal, have the remarkable property of absorbing oxygen in their pores, and the oxygen in this state, enters into combination with other bodies with great readiness and force. A remarkable example of this power of porous bodies was first given in this place by Dr. Stenhouse, who found that a dead cat, by being covered with only three inches of charcoal, could be kept in a sitting-room without giving off any sensible offensive smell. The odours resulting from putrefaction were thoroughly oxydized. Porous chalk has a like property; and the natural power of gases to diffuse is aided by the variations in the density of the air, which expands when the barometer falls, and is condensed when the barometer rises.

In this manner the water slowly loses all the organic matter contained in it, it becomes perfectly pellucid or clear, and at the same time unites, or takes in solution, a large proportion of atmospheric air, but absorbing a larger quantity of oxygen from the air than of nitrogen, as is the property of all pure water; so that the water in the lower stratum of the chalk is not only freed from putrescent organic matter, and becomes perfectly bright and clear, but is well aërated and oxygenated, to which the well-known freshness of spring-water is due.

I may here mention, in illustration of the oxydising power of chalk, what is well known in districts where the chalk appears near the surface. When ordinary wooden posts, such as are used in making fences, have their lower ends sunk into the ground, and are rammed up with chalk, the portion of the post in the ground will become completely rotten and decayed in four or five years; while posts, of the same size and material, fixed in the same manner, but rammed up with clay in a clay soil, will last twenty years, or more, and then be sound at their lowest extremity.

The carbonic acid formed in the pores of the chalk, as described, being dissolved in the water, causes it to take in solution a small portion of chalk in the state of bicarbonate of lime, and so thoroughly, that whenever a well or tunnel has been excavated through chalk, and moisture is present, there is no free carbonic acid to be removed, as is necessary in excavations in many other soils.

From a gallon of water taken from the chalk strata at Watford, there may be obtained by evaporation 23 grains of mineral matter, which were in a state of invisible solution; 17½ of those 23 grains consist of chalk, the remaining 5½ grains consist principally of silica and salts of magnesia and soda. The principal mineral or saline matter contained in the water is, therefore, chalk, held in solution by carbonic acid.

Owing to the water passing down through so great a depth into the chalk hills, and to the length of time occupied in passing down, the water assumes about the mean temperature of the air, or 52° Fah., and the water, when first raised, is at all seasons of this agreeable temperature.

The characteristics of the subterranean spring water from the chalk strata are, therefore:—

1st. Its clearness, brightness, and freedom from solid matter in suspension.

2nd. Its being always about the agreeable temperature of 52° Fah.

3rd. Its freedom from putrescent organic matter.

4th. Its holding in solution a large proportion of oxygen gas and atmospheric air.

5th. Its holding in invisible solution about 17½ grains of chalk per gallon.

If it were not for the chalk in the subterranean spring water, it would be impossible to find a water better adapted for domestic use. The chalk, however, held in solution, renders the water, what is popularly called hard, and ill adapted for washing and bathing.

It is easy, however, by a simple and inexpensive process, to withdraw from the water nearly all the chalk it contains, with the exception of 1½ grains per gallon, without leaving anything else in the water in the place of the removed chalk, and without altering any of its other good qualities; so that, after the water has had the chalk withdrawn from it, it still maintains the first four characteristics before named, quite unimpaired.

The following is an analysis by Dr. Thomas Clark and Dr. John Smith, showing the soluble contents obtained by evaporating a gallon of water, procured from the chalk stratum at Watford, before and after the withdrawal of the chalk, where each degree of hardness stands for as much hardness as would be produced by one grain of chalk per gallon:—

Analysis of the Evaporated Residuum of Watford Spring Water.

	Grains per Gallon.		Degrees of Hardness.	
	Original	Softened	Original	Softened
Carbonate of lime	17·60	1·65	17°·60	1°·65
Nitrate of lime........................	0·08	0·41	0°·05	0°·25
Nitrate of magnesia	1·42	1·05	0°·95	0°·70
Nitrate of soda........................	—	0·09	—	—
Sulphate of soda	0·50	0·50	—	—
Chlorides of sodium & potassium	1·30	1·30	—	—
Phosphates (precipitated by ammonia from acid solution)......	0·28	0·28	—	—
Silica	0·82	0·57	—	—
Volatile matter, including some nitric acid	1·00	1·15	—	—
Residue on evaporation	23·00	7·00	18°·60	2°·60
Subtract latent hardness (magnesian salts)............			0°·95	0°·00
Sensible hardness			17°·65	2°.60

The principle characteristics of the water when the chalk is withdrawn from it, besides those already named, are: 1st. Its softness being only $2\frac{6}{10}$th of a degree of hardness, or about as soft as ordinary rain water collected from the roof of a house, without any of its impurity.. 2ndly. That the water has no action whatever upon lead, as most soft waters have.

I have before shown, that the area of country having chalk at, or near the surface, in the south-east of England, amounts to 5,000 square miles. Assuming that only 12

inches in depth per annum, of the rain that falls on this surface, percolates down to the lowermost stratum of the chalk, finding its way in subterranean currents to the sea, this depth of rain on this surface would produce the enormous amount of 2,400 million gallons per day, for every day in the year. As every gallon of water thus flowing into the sea carries with it—held in invisible solution as bicarbonate of lime—on an average about 16 grains of chalk per gallon, which is equal to one ton per million gallons, we become aware of the fact that 2,400 tons of chalk are *daily* carried into the sea, by subterranean currents of water, that is to say, 100 tons per hour. When we bear this in mind, it is easy to perceive how the water draining down through the mass of the chalk hills makes an underground passage for its exit; and also, to account for the fact (which is well-known to all practically conversant with the working of chalk wells) that the water-bearing fissures in wells sunk in the chalk, get very much enlarged in a few years. I have known water-bearing fissures in the well sunk in the chalk that supplies the town of Brighton with water, not one-fourth of an inch wide when the well was first sunk, to be enlarged, in four or five years, to many inches in width. This accounts for the fact, that wells sunk in the chalk, continue for several years after they are first sunk, to yield water more and more plentifully.

The method of withdrawing the chalk contained in water was invented and patented by Dr. Clark, of Aberdeen, and the operation of the process has been explained by him in the following words:—

"To understand the nature of the process, it will be necessary to advert, in a general way, to a few long-known chemical properties of the familiar substance, chalk; for chalk at once forms the bulk of the chemical impurity that the process will separate from water, and is the material whence the ingredient for effecting the separation will be obtained.

"In water, chalk is almost or altogether insoluble; but it may be rendered soluble by either of two processes of a very opposite kind. When burned, as in a kiln, chalk loses weight. If dry and pure, only nine ounces will remain out of a pound of sixteen ounces. These nine ounces will be soluble in water, but they will require not less than forty gallons of water for entire solution. Burnt chalk is called quicklime, and water holding quicklime in solution is called lime-water. The solution thus named is perfectly clear and colourless.

"The seven ounces lost by a pound of chalk on being burned consist of carbonic acid gas,—that gas which, being dissolved under compression by water, forms what is called soda-water.

"The other mode of rendering chalk soluble in water is nearly the reverse. In the former mode, a pound of pure chalk comes to be soluble in water in consequence of losing seven ounces of carbonic acid. To dissolve in the second mode, not only must the pound of chalk not lose the seven ounces of that carbonic acid it contains, but it must combine with seven additional ounces of that acid. In such a state of combination chalk exists in the waters of London—dissolved, invisible, and colourless, like salt in water. A pound of chalk, dissolved in 560 gallons of water by seven ounces of carbonic acid, would form a solution not sensibly different in ordinary use from the filtered water of the Thames in the average state of that river. Chalk, which chemists call carbonate of lime, becomes what they call bicarbonate of lime when it is dissolved in water by carbonic acid.

"Any lime-water may be mixed with another, and any solution of bicarbonate of lime with another, without any change being produced: the clearness of the mixed solutions would be undisturbed. Not so, however, if lime-water be mixed with a solution of bicarbonate of lime; very soon a haziness appears, this deepens into a whiteness, and the mixture soon acquires the appearance of a well-mixed whitewash. When the white matter ceases to be produced, it subsides, and in process of time leaves the water above perfectly clear. The subsided matter is nothing but chalk.

"What occurs in this operation will be understood if we suppose that one pound of chalk, after being burned to nine ounces of quicklime, is dissolved so as to form 40 gallons of lime-water; that another pound is dissolved by seven ounces of extra-carbonic acid, so as to form 560 gallons of a solution of bicarbonate of lime; and that the two solutions are mixed, making up together 600 gallons. The nine ounces of quicklime from the pound of burnt chalk unite with the seven extra ounces of carbonic acid that hold the dissolved pound of chalk in solution. These nine ounces of caustic lime and seven ounces of carbonic acid form sixteen ounces—that is, one pound of chalk—which, being insoluble in water, becomes visible immediately on its being formed, at the same time that the other pound of chalk, being deprived of the extra seven ounces of carbonic acid that kept it in solution, reappears. Both pounds of chalk will be found at the bottom after subsidence. The 600 gallons of water will remain above, clear and colourless, without holding in solution any sensible quantity either of quicklime or of bicarbonate of lime."

This will explain the theory of the patented process which I have lately been called upon to apply in some works I have constructed for the purpose of supplying the parishes of Plumstead, Woolwich, and Charlton, with water derived from the chalk strata.

These works were commenced about December, 1852, and they were so far advanced that they were used to supply the spring water from the 1st August last year, afterwards the same water softened since the 1st of November. The wells, pumps, steam-engines, and principal works are situated at the top of Ann-street, Plumstead. The well is sunk into the chalk, which is here met with at about 60 feet from the surface of the ground. I found no difficulty in procuring an abundant supply of the water required by the company,

The water, after being pumped up from the well, is softened according to the process just described, cream of lime being used instead of lime-water. The process is found extremely simple, and very easy to work, and it appears probable that the sale of the chalk taken out of the water, which is similar to, but better in quality than, the best whiting, will repay the whole expense attending the process. I have here some of the chalk taken out of the water for you to examine.

The water at the Plumstead Works, after being softened, is pumped up into a covered reservoir, situated near Plumstead-common, and is furnished through pipes to the houses, on the continuous system, so that the consumers can draw the water at all times from the pipes of the company by merely turning a tap, without the intervention of any butt or cistern. The water is very much liked by the consumers for all purposes—drinking, washing, cooking, &c. Should any of you like to examine the water for yourselves, or to see the process in operation, I shall be glad to afford you the opportunity.

If in the foregoing statements I have been successful in conveying to you the facts and reasonings in my own mind, I think you will agree with me in the important conclusions that there exists within reach of the metropolis a source for the supply of water, abundant in quantity and unexceptional in quality.

DISCUSSION.

Dr. Hassall, in a letter to the Secretary, whilst regretting that indisposition would prevent his attending the meeting, and so taking part in the discussion, as he had intended, says:—"Water intended for domestic use should possess two characteristics—first, it should be entirely free from organic productions of every kind, dead and living; and, secondly, it should be soft. The waters at present in use in this metropolis fulfil neither of these indications—they abound with living productions, and they are not

of the requisite degree of softness. The water obtained from chalk strata, as proposed by Mr. Homersham, would certainly be free from the greatest and most injurious contamination to which it is liable, viz., that by organic matter, while the quality of hardness is one which admits of remedy, so far as I have hitherto had the opportunity of judging by the adoption of the softening process of Professor Clark (of Aberdeen). Almost any water which fulfils the above two indications, would be suitable for domestic use, no matter what the source might be from which it was procured."

Dr. Glover stated that in his opinion there were no positive data whatever as to what extent organic matter and animalcules might exist in water without being injurious; although, perhaps, a general notion might be formed on the subject.

Mr. Frederick Braithwaite apprehended that the discussion that evening was not so much the purity of the water from the chalk, as the question of the quantity of water to be obtained from that stratum; and, having heard the principal part of the paper read to-night he was surprised that, in the face of the positive evidence of the inefficiency of the supply from the chalk, the author of the paper should still persist in stating that it contained a quantity which did not really exist. The drawings which he saw before him he recognised as having been exhibited in other places where this question had been discussed. He was mistaken if he had not seen them at the House of Commons, and also at the Institution of Civil Engineers, the matter having been discussed by the latter body, he believed, on no fewer than nine nights, on various occasions. Therefore, any remarks he might offer would, perhaps, appear more like a repetition of what he had said before rather than as original to the present occasion. He had at different times combatted the observations of the author of the paper, for unfortunately his facts went against Mr. Homersham's theory. He (Mr. Braithwaite) did not make any pretensions to greater geological knowledge than others present, but when he had been called upon to perforate the chalk in almost every part of London, and when the results had proved that it was a fallacy to hope for any very large supply of water from the chalk, he hoped he should not be considered personally offensive when he said the author of the paper was perfectly in error upon this subject. Localities had been pointed at—such, for instance, as the Orange-street well —as yielding, it was alleged, an inexaustible supply of water from the chalk. He wished to state that that inexhaustible supply was not from the chalk at all, but from the sand overlying the chalk; but even assuming that the well was inexhaustible for its purposes, it was not inexhaustible as to the supply of London with water. They could imagine a great number of wells of which it might be said that the supply of water was inexhaustible, inasmuch as it had perhaps never been known to run short for the purposes to which it was applied; and, for the simple reason that the supply had been equal to the demand, it was alleged to be inexhaustible. For instance, supposing a person having a well in London required 20 gallons of water per minute; if the supply was 30 gallons per minute, and only 20 gallons were required, it was stated to be inexhaustible; but suppose that person wanted 40 gallons per minute, then the reverse would be the order of the day. He had taken infinite pains to look into this question, and there was one fact he would like to mention, although it was not original, referring to the quality of the water, as in many parts of the paper the author had touched upon this branch of the question. When the well was sunk at the Camden-town station of the London and North Western Railway, they found to their surprise that the water which was tapped from the chalk did not rise to within 44 feet of the Trinity high-water mark. The same railway company had also chalk wells at Watford and at Tring, but it was a singular fact that when they filled the boilers with the water from the Camden-town well, they could not keep it in the boilers, because it what was technically termed "primed," and the surprise was, how the water at Watford and Tring should be so good, whilst that at Camden-town could not be used for the locomotives. It was found, upon analysis, that the water at Tring and Watford contained from 17 to 19 grains of carbonate of lime per gallon, and 2¼ grains of saline matter, whilst that at Camden town contained 44 grains of saline matter per gallon, with very little carbonate of lime. This remarkable difference in the chemical conditions of the water formed the subject of a discussion at the Institution of Civil Engineers, and on that occasion he took the liberty of differing very widely from the opinions expressed by several of the speakers as to the cause of this difference. For his own part he attributed it to the infiltration of water from the sea, or the brackish water of the Thames under London. For this reason, the waters under London varied in their chemical condition—for instance, the water of the Orange-street well contained nearly 100 grains of sea salt per gallon; whilst that at Watford contained but 2 grains per gallon. The fair question was, if there was this inexhaustible supply through the chalk, how was it they had this infiltration of salt? The fact was there was no such supply. He would mention the fact, that in a boring made in 1832, the water rose in the well to the Trinity high water mark, and an analysis showed that that water contained nothing like the same amount of salt as was now found under the same circumstances. He had in his hand a table, showing the level of the water in a well situated not more than a quarter of a mile from the Orange-street well, namely, at Combe's brewery. This well was first sunk, he believed, in 1827, and as he had said, the water at that time rose to the level of the Trinity high-water mark. He had no opportunity of taking the gauges of that well until the year 1837, but from that period to the present time he had gauged it accurately and minutely; and the result had been to show the permanent lowering of the water under London, not in one instance only, but in all cases that had come under his notice throughout London. In the year 1832, the water in ten or twelve of the principal wells in London also rose to the Trinity high-water mark. The table to which he had alluded gave the rainfall every month from year to year, and they would see that it showed an abstraction from the basin of some 500,000,000 or 600,000,000 of gallons a year, and it moreover showed the continuous lowering of the water under London. Now he wished to know what became of the argument that so many inches of water flowed into the bowels of the earth to make up the supply. On the contrary, they found that they had much infiltration of salt and sea-water, and in all cases where they had gone a considerable depth into the chalk, and, in some instances, even through the chalk, they had never yet met with what he should call a supply of water. In the case of the well at Reid's brewery, the chalk was bored and tunnelled in every direction, and they got a supply of 190 or 200 gallons per minute, but, at the present time, that supply had fallen to 30 gallons per minute. At Hampstead, again, where they had gone completely through the chalk, and had bored to a depth of 600 or 700 feet, they had found no water in the chalk; and the chalk, as chalk, he contended, did not give out one drop of water. If they got it at all, it was through the fissures, and even those were diminishing in their supply. In the Chiltern Hills there were large fissures, besides a tolerable supply from the surface, and Mr. Homersham had correctly stated that large quantities of fresh water ran into the sea from the chalk formation at Brighton and Ramsgate; but the chalk formation under London was of a different character. He mentioned these as ascertained facts, and he would challenge any one to show him any instance in London of such a supply of water being obtained from the chalk as would be adequate to the requirements of this vast city, though he admitted they might find limited supplies. He regretted that there should be a difference of opinion upon a question of facts. The Rev. Mr. Clutterbuck had

paid great attention to this subject, and he felt sure that that gentleman would corroborate his assertion, that it was a mistake to suppose that, because here and there fissures were met with which yielded a large supply, that therefore the supply was inexhaustible. It had been asserted that there were from eight to ten inches of water flowing under London, but if they went into the calculation he questioned whether there was more than the tenth of an inch at the present time. In 1852 there was a large rain-fall, and if a great proportion of this sank into the chalk strata, how was it they had this constant depression of the water only from a limited abstraction, and yet it was the same in every part of London.

The Rev. J. C. CLUTTERBUCK said, in dealing with the points raised in this paper, he had not much new matter to introduce, considering that this subject had been already so largely discussed at the Institution of Civil Engineers. It was clear that the chalk strata were the sources of the supply of water to the metropolis, and to a certain extent they always would be so, although he had heard of an extraordinary proposition to bring water out of Wales for the supply of London: but, as nature had made the London chalk basin the natural means of supply, so it would continue. Let them look at what was the state of the metropolis before it became inhabited by its present teeming population. They found it to consist of a bed of gravel, resting upon clay, which bed of gravel did, no doubt, to those who first fixed their habitations here, yield to them a tolerable supply of water. Certainly their forefathers would not have built a town where there was no water, and they unquestionably fixed upon London as a proper place because there was a supply of water. It was, in times gone by, obtained from wells, but it might now be said that that supply was pretty well exhausted. No one in the present day thought anything of what were called land-springs, which gave a great deal of trouble perhaps to those who sank wells, though to no one else. It was stated that the metropolis was indebted to a Dutchman for its first supply of water. Then came the project of Sir Hugh Middleton, who, by diverting streams, brought a supply of water to London: his work had outlived him, and the main works were still in existence. That was the natural way of dealing with the question. The supply of water at the New River Head, coming from Hertfordshire, still went on, and was made available for the requirements of the population of a very large portion of the metropolis. There were, in addition, the supplies taken from the Thames, which were still going on; and, with reference to the Thames, he might say, that a great deal of the volume of water of the Thames was derived from the chalk. There was a large drainage of water from the Chiltern Hills into the Thames, which found its way into Berkshire and Oxfordshire. Then, if they went further up the stream, they found it received a great quantity of water from the gap near Pangbourne. Then, going on towards Reading they found the Kennet coming into it, and also the little stream which came by Wycombe, until they got to the Colne—so they might naturally say chalk was the stratum which yielded the principal supplies of the Thames. But now that they were looking for supplies from artificial sources, what was the consequence? At the beginning of the present century it was discovered that, by boring into the sand and chalk, large supplies of water might be obtained by Artesian wells. They acted very well for some time, and there were not wanting persons who declared that the supplies from those sources were inexhaustible. Against such a declaration he would place the statement, derived from actual experience, made by Mr. Frederick Braithwaite. He (Mr. Clutterbuck) was not prepared to say there were no exceptions, but they had the fact before them, that there was a depression of sixty feet in the wells of London, and he had no doubt of the accuracy of Mr. Braithwaite's statement. He had suggested, in a paper which he had read before the Institution of Civil Engineers in the year 1850, that it was in consequence of the back drainage of the Thames, to fill up the vacuum, that the large quantity of salt found in the water was due; and he had no doubt that would be found to increase every year in the deep wells of London. Here was an instance in which they had tried to deal with the supply of water from artificial sources, and not according to the natural mode either by the New River, the Croydon River, or the Thames, and that ought to be a warning as to how far they ought to go in tampering with those supplies. In dealing with the question before them he thought due weight had not been given, in the beginning of the paper to the amount of evaporation of water from the soil. It was quite true that the water which fell upon the surface was, to some extent, immediately evaporated, particularly in hot weather; another portion entered into animal and vegetable life, whilst a further portion either ran off the surface or sank into the ground where the stratum was porous. But they were to remember this, that when the water was evaporated from the soil the first duty of the water which permeated into the stratum would be to replace that which had been so evaporated. People were little aware of the enormous bulk of water that evaporation would consume. He stated before another society, the other day, that, from his own experience and observation, he had found, at the end of a dry season, it would consume at least three inches of continuous rain to replace the water which had been evaporated during the dry season. Now, if they took three inches of water from the whole annual rainfall, and also remembered that during the whole of the summer there was a rapid evaporation going on, they could not look for much supply of water from that source—namely, the rainfall. Sometimes they had as much as two inches of rain in one week, and he had known more than an inch in twenty-four hours, and on one occasion he registered between two and three inches in three or four hours, but such a fall as that would generally occur in the month of July, when the ground was very much heated, and much water was sucked up. Chalk, it had been found, would absorb about one-third of its bulk and one-fourth of its weight of water. The quantity of moisture appropriated by the soil to replace the water evaporated was immense, and, so far from saying that 12 inches of rain sank into the earth, he never knew anything like that quantity, and he would affirm that during the last 15 months not so much as 2 inches of rain had sunk into the soil. He had not brought with him the register of Mr. Dickenson's gauge, but he had gone upon the principle of gauging the wells themselves, which appeared to him the most legitimate mode—and he recollected in a wet season in June, he gauged and found the rise was only about 2½ or 3 inches. Some reference had been made in the paper to the conformation of the strata under London, and the term "basin," as applied to these strata, seemed to be objected to; but when they spoke of the London basin, no one imagined that it was as regular in its form as a washing-basin, for instance. He presumed that what was meant was an indentation filled up with some other strata; but it was not necessary to dwell on that. A great point had been made of the drawings of bridges exhibited. His old friend, Dr. Buckland, used to say with reference to the chalk districts, where floods never occurred, that in Hampshire they built the arches of the bridges so low, that the ducks had to bob their heads when they went under them. It was evident that they had no floods, or they never would have built such bridges. He had no doubt the drawings produced by Mr. Homersham were correct representations of the different bridges in the chalk and in the clay districts, although he thought it did not go to prove very much, inasmuch as if they went to one of these smaller bridges after a heavy thaw, they would find very little difference in the height of the water there, but then in this case the water was running continuously, whereas in the other it was principally at seasons of floods. Not long since, after a considerable fall of rain, he saw a plough at work in a field which turned up complete dust at only

such a depth as the plough would reach, and therefore he was at a loss to know what great point was made by showing that the clay had more evaporation from it than the chalk. That was no proof that all the water went into the chalk, because there was a portion of soil which sucked up the water. He could not agree with Mr. Homersham with reference to the absorption of water by chalk. As far as he could judge, if they took a piece of chalk and saturated it with water, they might hang it up, and he ventured to say it would not part with a drop of the water except by evaporation. He had made an experiment for the purpose of ascertaining how much water chalk would take up by capillary attraction. He filled a glass tube with about thirty pieces of chalk of the size of the top of the finger, with only the bottom piece immersed in water, and it was a considerable length of time before the top pieces became affected by the moisture from below. The conclusion at which he had arrived was, that the chalk would absorb one-third of its bulk and one-fourth of its own weight of water. There were many different qualities of chalk, but he was speaking of the clean, smooth chalk which a carpenter would use, containing 95 per cent. of carbonate of lime, and that description would take up the quantity of water he had stated; and it was not until that quantity had been taken up that any water would pass through the fissures. He did not understand that the water was driven through the chalk, but only passed through it between the cracks and fissures. With reference to the well alluded to by Mr. Homersham as giving 750,000 gallons per day, he begged to ask that gentleman at what period that supply was given?

Mr. Homersham said it was in July, 1853.

Mr. Clutterbuck.—In 1852 they had a very heavy rainfall, and if the supply was 750,000 gallons per day in 1853, he would almost stake his existence that it was not half that quantity at the present time.

Dr. Clark, of Marischal College, Aberdeen, remarked that it had been somewhat authoritatively given out by the two gentlemen who had preceded him, that because, forsooth, this subject had been discussed for nine nights at the Institution of Civil Engineers, there was no scope left for discussing it here, but it did not occur to him from what transpired of the proceedings of the learned Society alluded to, or from what had that evening fallen from the gentlemen who had just addressed the meeting, that the subject had been removed from intelligent discussion in this place. He did not intend to discuss this subject geologically, and he would leave to the author of the paper to answer in detail the objections which had been taken to his theory. One gentleman (Mr. Braithwaite) had met the statements of the author of the paper by saying—such and such was not the fact—which was a style of settling matters that he (Dr. Clark) was not accustomed to. What was the state of the case? A certain portion of clay was here represented whereon London stood, and that gentleman had said he knew there was not to be found under that clay the vast quantity of water described to be readily found, not under that clay, but beyond the limits of the overlying clay. As well might a man say, "I have had much experience in boring for water somewhere in the Isle of Wight, and having been accustomed to find little there, I can assure you there is little to be found in the chalk of Watford." The fact was notorious, that they could not get such large quantities of water from chalk under a load of superincumbent clay. Mr. Homersham had fully admitted that. But did Mr. Braithwaite say, "I went to Watford and I bored there, and I could find no water?" That would have been to the purpose. The inapplicability of the argument was further shown from this circumstance—whether or not the theory of Mr. Braithwaite was right, that the water of the Orange-street well came from the sand; it was known that the water found there was of a totally different quality from that obtained from the chalk beyond the London clay. Still the quality was such as could not be accounted for by the sea-water mixing with the water from chalk not loaded with clay. If they took chalk water and sea water and mixed them together in any proportions, it was physically impossible to make out of the two a water corresponding to the chalk water under London; and therefore that theory was simply a mistake; and it was also a very great mistake, as to the scientific result of chemical analysis, to say that in the water found below London there were something like 100 grains of salt per gallon. There was not 100 grains per gallon of all sorts of things in it. He had a friend sitting near him who told him he had accurately examined these waters, and he said it was no such thing, and moreover that a very small portion of salt only was present. There was this fact also worth stating—if they went to any of the chalk formations not being heavily loaded above with clay, they would find that the quality of the water was singularly uniform; the only difference was, that they would find more water in some places than in others. In some cases it contained 23 grains of saline matter per gallon, and in others only 19 grains, but the dissolved matter was so nearly the same, that you might say the one water had 23 grains in a gallon, and the other had 23 grains in more than a gallon; whereas the waters below London are of a different nature. They would find that the same weight of saline matter evaporated from the water of the Orange-street well and from the water of the well at Combe's brewery, presented considerably different results of analysis, so that all the observations with reference to the water below London, were nothing to the purpose in hand. If the chalk below London was so compressed as that there was not free scope for the water to pass through the interstices towards the sea, it would find its way through places where there was not that compression. With regard to the observations of Mr. Clutterbuck as to evaporation, what struck him (Dr. Clark) most was the loose kind of evidence which the rev. gentleman had produced upon that subject, and how utterly unlike it was to the stern, rigid, and undeniable evidence which belonged to all scientific investigations.

The Rev. J. C. Clutterbuck said he had given the results only, but would be happy to furnish the details if they were required.

Dr. Clark went on to remark, that it had been said the discussion of this paper should have reference to the quantity and not to the quality of the water, as a source of supply to the metropolis. That notion, certainly, did not occur to him; on the contrary, if they obtained a source as ample as the sea, unless the quality of the water was such as to make it fit for use by the inhabitants of the metropolis, the quantity went for nothing. With regard to the presence of organic matter in water, some people hereabouts entertained the idea that all water contained minute living creatures, and that it was an arrangement of nature that every one should patiently submit to. For his own part, he was 28 years of age when he first visited London, but, until then, he had never seen a live insect in water supplied to a town; and in the town where he now resided, although the water came from the river, they could not see an insect in it with the naked eye, and it was difficult to discover any with a microscope. There was no doubt a diversity of tastes as regarded water, as in all other things. Some might not think the presence of organic matter an objection. In some specimens of the Thames water, as recently supplied, he was aware that the microscope discovered traces of the fibre of mutton chop, the source of which it were perhaps too curious to inquire into. For his own part, he prefered to have water free from all organic matter. There was this plain advantage in supplying a town with water free from organic matter, that such persons as were disgusted with this kind of matter would be gratified by its absence, whilst others, that prefered the contamination, might add of it as much as to make the water suitable to their taste. At the same time, it was notorious that water contaminated with organic matter, under certain circumstances—for instance, in very hot weather—became

very offensive, both to the taste and smell, and there could be no doubt, notwithstanding the uncertainty of the history of epidemics, that, somehow or other, corrupted water was connected with the cause of some epidemics. He believed the chalk water which Mr. Homersham referred to—not the water under London, which was of different quality—but taken from favourable positions, could be obtained devoid of organic matters, which would be a prodigious public advantage; for sometimes they found families, who were accustomed to drink water, on coming to London were disgusted with the article they were supplied with; and in preference they drank something else, not so good nor so cheap as wholesome water. He contended that organic matter was the chief pollution of water, but spring water might be obtained from the chalk entirely free from it. He might enumerate a few of the advantages of a supply of water such as was proposed by Mr. Homersham. They would, in the first place, have water free from organic matter, or if any trace of it were detected, the process which Mr. Homersham had described took it away—a fact which he had himself carefully verified. They would, in addition, have water containing only 7 grains of saline matter per gallon, and only one-fifth of the hardness at present supplied. The softness of the water was an advantage in other respects beyond the saving of soap in the operation of washing, and since the supply had been laid on from the New Woolwich Waterworks the laundresses had been able to get up their linen whiter and clearer than they were before enabled to do. He thought Mr. Homersham had made out, in a satisfactory manner, that an enormous quantity of water is dispersed throughthe chalk; and to his mind that gentleman had given a very reasonable account of what became of it. For his own part he would say that he had not yet heard of a proper search for chalk water, in such places as Mr. Homersham had referred to, that had not been attended with success. In this metropolis water might now be got so soft and pure that he did not know a large town which was more highly favoured than this great metropolis *might* now be.

Mr. EVANS said he had been an inhabitant of Watford for upwards of 15 years, and was well acquainted with the district, having sunk wells and constructed weirs for manufacturing purposes, the supplies of water to which were derived from streams arising from the chalk. The basis of Mr. Homersham's calculations appeared to be this:—a certain amount of rain-fall took place annually, and a certain quantity of the water was carried off by springs and rivers, and a certain quantity by evaporation. It was about 19 years ago, that, for the sake of gathering information as to the quantity of rain-fall in successive years, he employed a gauge constructed upon the plan of Dr. Dalton, in which the rain which fell upon the surface soil, was collected after percolation through three feet of soil, defended from evaporation. The result showed that the average annual rain-fall of the 19 years was 26 inches, whilst the quantity which had percolated through the soil was less than 9 inches. The soil of Watford was covered with a clay or sand of the beds of the lower tertiary formation, which tended to diminish the amount of the body of water percolating into the chalk. He took the full amount of the flow at London-bridge, and the gathering ground of the river, and he found that the quantity of water taken, as being the amount of the stream at London-bridge, corresponded with his calculations. It showed that the whole of the water which percolated to any depth, was accounted for by the streams and rivers of the districts and if any of the water fell towards the sea it must be a very minute quantity. Mr. Evans went on to mention, that two years ago he constructed another Dalton gauge, and filled it with pure chalk, with nothing on the surface, and during the last year—from February to December, not a drop of water had percolated through that three feet of chalk. He thought that showed that the absorbent powers of chalk had been much over-rated. With reference to the wells sunk in connection with the Woolwich and Plumstead water works, Mr. Evans mentioned that on a property held by a relation of his, the well had been laid dry from the pumping of the company's well; also that a well sunk by the Grand Junction Canal Company, to a depth of 72 feet in the upper and middle chalk, had the effect of laying dry a stream which worked one of his mills, and he obtained an injunction to restrain them from pumping that well, so that it was evident puddling did not prevent the surface water from being abstracted, which was sometimes a matter for which compensation was demanded.

After a few words from Mr. Braithwaite, and Mr. C. May having declined to protact the discussion at the late hour to which it had extended,

Mr. HOMERSHAM begged to say a few words in reply to one or two points in the discussion. Mr. Evans spoke of compensation,—very natural to a mill-owner, who sought not for compensation for the value of any damage done, but ten or twelve times the value of a supposed injury. Mr. Braithwaite had stated that at Southampton they had bored in one place 1,000 feet in chalk below the clay, and yet found no water. Granted that was the fact, yet, in the chalk at a few miles out of the town they had got more water than was wanted to supply ten Southamptons. In the well or boring to which Mr. Braithwaite referred, the chalk was hard and impermeable, from a thick body of clay overlying the chalk, and they got no water from it, but on going a few miles out of the town, where there was no clay, an abundant supply was obtained. The New River Company sunk a well at Hampstead, where the chalk was thickly covered with clay, and obtained 600,000 gallons per day; but they went further out of London, and sunk two wells near Ware, where the chalk was not covered with clay, and then got a supply of 4,000,000 gallons per day. He had never said that they could get water in any large quantity from the chalk under thick London clay. It was foreign to the purpose for Mr. Braithwaite to come here and tell them that, and try to argue from it, that they could not get water at Watford. Nor was the water under London of a quality which was desirable for the supply of London. He repeated, that when they went to chalk where the clay did not lie upon it there was a different state of things, and in suitable localities they got, *practically*, an inexhaustible supply of water. He would add one word with regard to the gauge which Mr. Evans stated Mr. Dickenson had used to ascertain the infiltration from the annual rain-fall. When before a Parliamentary Committee he had occasion to learn all about that gauge, and he had prepared evidence to be given before the committee, and had had drawings made of the gauge. It was as unlike the gauge recommended by Dr. Dalton as it was possible to be. There was an overflow pipe attached to it without a bottle to catch the water, and there was a stratum of peat, which was well known to have the property of plugging up pores, and hindering filtration, put on the earth at the top of the chalk, and the body of the gauge was made of wood not tight at the joints, and therefore for the purpose of telling what quantity of rain infiltrated through the chalk, the gauge in question was quite useless. How far the experiment was properly conducted upon the gauge with the bare chalk referred to, he could not say without having all the particulars before him. Mr. Evans had alluded to the beautiful greenness of the vegetation of the Chalk Downs. Now he (Mr. Homersham) could only say, that the land on the Chiltern Hills would not let for more than 10s. or 12s. per acre, but in the neighbourhood of the Brent it let for £3 or £4, where there was five or six times as much grass as upon the chalk downs or the Chiltern Hills, and therefore it was evident that less water must be consumed by vegetation on the chalk downs than on the London clay at the Brent. He would state that there were 270 square miles of chalk country on the Chiltern ridge which contained hardly a

spring or a stream, and the vegetation was of the most scanty description. With regard to the well at the Cow Roost, to which Mr. Evans had alluded, it was not puddled water-tight on the sides, nor was puddle carried down to the bottom of the well; and he had said that if in proper localities they constructed wells lined with impermeable sides, carried into a hard stratum of chalk, they might get a large supply of water without interfering with the springs, rivers, or sources from which other wells in the neighbourhood were supplied. Mr. Evans had argued that if wells were sunk near a river they would obtain water from the river; but, if so, a well 40 feet deep would do this better than one of 80, as the deeper the bottom of the well the farther from the river. He would say that at Watford they did not get, in wells, any very large quantity of water, at a less depth than 120 or 160 feet, and they could not get much water at 40 feet deep. Mr. Homersham then referred to the well at Great Grimsby Dock, as another illustration of the position he had taken. The bore-hole of that well was 24 inches in diameter, and was found capable of supplying 8,000,000 or 9,000,000 gallons per day of the purest water.

The CHAIRMAN, in summing up the discussion, said the practical question to be solved was whether the chalk stratum could be depended upon for obtaining a very large supply of water. According to Mr. Braithwaite, who had had very considerable experience in this matter, they could not depend upon the supply for any length of time, where the chalk was covered with London clay. The question was, the limit of the quantity; and, further, whether in tapping that water they did wrong or not to the present surface supplies of water. It therefore still remained to be established what quantity of water could be depended on for a long period of time from the chalk, which had not as yet been adequately tested.

The Secretary announced that there would be a *Special* Meeting on the evening of Friday, the 2nd of February, when Mr. Leone Levi would read a short Paper, "Observations on the Proposed Congress for the Improvement of International Commercial Law," as introductory to a discussion on that question.

Also, that the Paper to be read at the meeting of Wednesday, February 7th, was "The Commercial Consideration of the Silk Worm, and some of its Uses," by Mr. Thomas Dickins.

ON THE CONSTRUCTION AND PROPER PROPORTIONS OF BOILERS FOR THE GENERATION OF STEAM.*

By ANDREW MURRAY, M. INST. C.E., CHIEF ENGINEER OF H.M. DOCKYARD, PORTSMOUTH.

Mr. Muir, in his paper on the Smoke Nuisance, read before the Society on the 17th of January, referred, and other parties have done the same, to a want of definite rules for the relative dimensions for the flues and other parts of steam engine boilers. In 1844, in a paper read before the Institution of Civil Engineers, Mr. Andrew Murray gave the results which he had arrived at, on these points, after long observation and much consideration. As his experience since 1844 has confirmed him in the opinions then expressed, he has enclosed to the Secretary a copy of the paper, from which the following extracts are taken.

"The supply of the requisite quantity of air to the fuel on the bars, being of the utmost importance, it is usual to make the ash-pit, and the entrance to it, as large, and as free, as the situation will allow. In marine boilers, or wherever it is necessary to limit the size of the ash-pit, the area for the entrance of the air into it, should never be less than one-fourth part of the area of the grate, and in order to facilitate the supply to the back part of the grate, the bars should be made to incline downwards to the extent of about 1 inch in a foot. No advantageous results will be obtained from increasing the ash-pit, as is sometimes done in land boilers, to a very great extent, by making it 5 or 6 feet deep; about $2\frac{1}{2}$ feet is sufficiently deep, even supposing that the ashes are not cleared out oftener than once a day.

"The extent of 'dead plate' in front of the furnace is not material, as respects combustion; in marine boilers, it is generally not more than about 6 inches broad, which is the width of the water space between the fire and the front of the boiler; but in land boilers it is frequently required to be very broad, to support the brick-work, especially in those cases where the flue is carried across the front.

"The amount of the opening between the bars, should be about $\frac{7}{16}$ths of an inch, but this must be regulated by the kind of coal to be burnt upon them; but for any kind of coal, it should not be less than $\frac{3}{8}$ths of an inch, nor more than $\frac{1}{2}$ an inch. If the space were made larger, the waste from the amount of cinders, or of small pieces of coke, which would fall through in a state of incandesence, would be considerable; otherwise it would be preferable to have a larger space. In order to facilitate the supply of air, each bar should be as thin as is consistent with the strength required. The bars in general use in this country, are 1 inch or $1\frac{1}{4}$ inch in thickness, but it would be much more advantageous to use them thinner, as in France, where they are frequently used not more than $\frac{1}{2}$ inch thick.

"The advantage of a considerable amount of space in the furnace, over the fire-bars, has been already mentioned, but no very decisive experiments have been made on this subject. Three cubic feet of space to each superficial foot of grate bar surface, may be stated as a good proportion where there is nothing to prevent this amount being obtained. When the space is reduced below one foot and a half to each foot of grate, it will be found to be attended with a marked disadvantage.

"The area of the flue, and subsequently of the chimney through which the products of combustion must pass off, must be regulated by their bulk and their velocity. The quantity of air chemically required for the combustion of one pound of coal, has been shown to be 150·35 cubic feet, of which 44·64 enter into combination with the gases, and 105·71 with the solid portion of the coal. From the chemical changes which take place in the combination of the hydrogen with oxygen, the bulk of the products is found to be to the bulk of the atmospheric air required to furnish the oxygen, as 10 is to 11. The amount is therefore 49·104. This is without taking into account the augmentation of the bulk due to the increase of the temperature. In the combination which takes place between the carbon and the oxygen, the resultant gases (carbonic acid gas and nitrogen gas) are of exactly the same bulk as the amount of air, that is, 105·71 cubic feet, exclusive, as before, of the augmentation of bulk from the increase of temperature. The total amount of the products of combustion in a cool state would therefore be $49{\cdot}104 + 105{\cdot}71 = 154{\cdot}814$ cubic feet.

"The general temperature of a furnace has not been very satisfactorily ascertained, but it may be stated at about 1000° Fahrenheit, and at this temperature, the products of combustion would be increased, according to the laws of the expansion of aëriform bodies, to about three times their original bulk. The bulk, therefore, of the products of combustion which must pass off, must be $154{\cdot}814 \times 3 = 464{\cdot}442$ cubic feet. At a velocity of 36 feet per second, the area, to allow this quantity to pass off in an hour, is ·516 square inch. In a furnace in which 13lbs. of coal are burnt on a square foot of grate per hour, the area to every foot of grate would be $\cdot516 \times 13 = 6{\cdot}708$

*Excerpt Minutes of Proceedings of the Institution of Civil Engineers, for 1844.

square inches; and the proportion to each foot of grate, if the rate of combustion be higher or lower than 13 lbs., may bè found in the same way.

"This area having been obtained, on the supposition that no more air is admitted than the quantity chemically required, and that the combustion is complete and perfect in the furnace, it is evident that this area must be much increased in practice, where we know these conditions are not fulfilled, but that a large surplus quantity of air is always admitted. A limit is thus found for the area over the bridge, or the area of the flue immediately behind the furnace, below which it must not be decreased, or the due quantity could not pass off, and consequently the due quantity of air could not enter, and the combustion would be proportionally imperfect. It will be found advantageous in practice to make the area 2 square inches instead of ·516 of a square inch. The imperfection of the combustion in any furnace, when it is less than 1·5 square inch, will be rendered very apparent by the quantity of carbon which will rise unconsumed along with the hydrogen gas, and show itself in a dense black smoke on issuing from the chimney. This would give 26 square inches of area over the bridge to every square foot of grate, in a furnace in which the rate of combustion is 13 lbs. of coal on each square foot per hour, and so in proportion for any other rate. Taking this area as the proportion for the products of combustion, immediately on their leaving the furnace, it may be gradually reduced, as it approaches the chimney, on account of the reduction in the temperature, and consequently in the bulk of the gases. Care must, however, be taken that the flues are nowhere so contracted, nor so constructed as to cause, by awkward bends, or in any other way, any obstruction to the draught, otherwise similar bad consequences will ensue.

"An idea is very prevalent that it is advantageous to make the flame, or hot gases (as they may be termed, because we may look upon flame merely as a stream of gases heated to incandescence) impinge upon, or strike forcibly the plates of a boiler, at any bend or change of direction in the flue. The turn in the flue is, therefore, made with a square end, and with square corners; but it is difficult to see on what rational grounds the idea of advantage can be upheld. The gases, if they are already in contact with the plate, cannot be brought closer to it, and any such violent action is not necessary to alter the arrangement of the particles of the gases and bring the hotter particles to the outside, while there is a great risk of an eddy being formed and of the gases being thrown back and returned upon themselves, when they strike the flat opposing surface; thus impeding the draught and injuring the performance of the boiler. That circulation will take place to a very great extent, among the particles of heated gases, flowing in a stream even in a straight flue, will be apparent from those particles next the surface being retarded by the friction against the sides and by their tendency to sink into a lower position in the stream, from their having been cooled down and become more dense. An easy curve is sufficient to cause great change in the arrangement of the particles, as those which are towards the outside of the bend, have a much longer course to travel and are thus retarded in comparison with the others. From these causes the hotter particles in the centre of the flowing mass, are in their turn brought to the outer surface and made to give out their heat. The worm of a still is never found returning upon itself with square turns, as if the vapour inside would be more rapidly cooled by its impinging on the opposite surface; yet the best form of worm is a subject which has engaged the attention of many able men, and therefore may well be taken by engineers as a guide in the management of a similar process, though carried on at a much higher temperature.

"Another very prevalent practice and which also would seem to be open to serious objections, is, that the flues are frequently made of much greater area in one part than in another. This arises from a desire to obtain a larger amount of heating surface than is consistent with the proper area of the flue, or with the amount of the heated gases which are passing through it. The flue is thus made shorter in its course than it ought to be in proportion to its sectional area. This is even sometimes done, by placing a plate of iron partly across the flue, near the bottom of the chimney, thus suddenly contracting the passage for the gases. The effect of this is evidently to cause a very slow and languid current, in the larger part of the flue, and the consequence is, that a deposition of soot rapidly takes place there. In many marine and land boilers, having one internal flue in them, of too large a size, this will be found to be the case, soot being soon deposited, till the flue is so filled up that the area left is only such as is due to the quantity of heated gases passing through it; the value of those parts of the sides of the flue which are covered with soot is thus lost.

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"When the gases have reached the foot of the chimney, in a well-proportioned boiler, they will be found to be reduced to a temperature of about 500° Fahrenheit, or below it; their bulk will, in consequence, be reduced by about $\frac{1}{3}$rd below their bulk on their first leaving the furnace. The reduction in the area of the flue, ought not to be in the same proportion, because their velocity is no longer so great. The reduction ought to be made gradually, as has been stated before, and not by a sudden contraction at the foot of the chimney, as the effect of this is to cause a slowness of draught in the latter part of the flue and consequently a deposition of soot; and then the surface, so covered, which had been reckoned upon as effective heating surface, is lost. The area of a chimney, to allow the products of the combustion of each pound of coal consumed in an hour, to pass off, should be not less than $\frac{3}{4}$ths of 2 square inches, this latter being the area given for the flue, immediately behind the fire-place—that is, $1\frac{1}{2}$ square inch; and for a boiler burning 13 lbs. of coal per hour, on each superficial foot of its grate, the area should be $\frac{3}{4}$ths of 26 square inches, or $19\frac{1}{2}$ square inches.

"Theoretical research not having as yet given us any valuable assistance, in determining the proper height of a chimney, we must again refer to practice as our guide. A good draught may be obtained with a very low chimney, but at a great expenditure of fuel, from the necessity that exists in such a case for allowing the gases to pass off at a much higher temperature than would otherwise be necessary. For a chimney built of brickwork, the height ought not to be less than 20 yards, and may be increased to 30 yards or 40 yards, with advantage in the economy of fuel. When chimneys are carried to a still greater height, it is generally for the purpose of carrying off the smoke, or any deleterious gases, from the immediate neighbourhood, or to create a good draught with gases at a lower temperature, than those from a steam-boiler furnace. On board steam vessels chimneys are limited in their height by the size of the ship, on account of the influence the chimney has on the stability and appearance. It will generally be found advantageous to make the chimney as high as these circumstances will permit."

LECTURES AT INSTITUTIONS.

Mr. Jelinger Symons has lately given gratuitous lectures on "Education, and How to Adapt it to the Practical Uses of Life," at the Bristol Athenæum, and the Mechanics' and Literary Institutes of Westminster, Ludlow, Shrewsbury, Hereford, Swansea, and Gloucester. At the three latter places very interesting and animated discussions ensued, in which several clergymen, professional men, gentry, and school-teachers took part. At Hereford, where Dean Dawes presided, the discussion was adjourned, and occupied two evenings. It is likely to result in the establishment of an evening institution for class instruction to adults in that city. Mr. Symons touched principally on the chief defects of school in-

struction, and the means of improving it; on the necessity of adapting education in the middle and higher ranks more closely to the individual capacities and social requirements of each class and sex, and on the full development of the moral, and, especially, the industrial faculties. He has also advocated Mechanics' Institutes, and the best manner of assimilating their functions to the tastes and necessities of the working-classes, and he has dwelt forcibly on the influence of individual character in every-day life on national welfare, and the consequent importance of making education tend to leaven society with its influence, and strengthen the energies and moral manhood of the people.

Mr. Symons suggests, that if gentlemen who have occasionally an evening to spare, would give similar lectures in their neighbourhoods on any popular subject with which they are familiar, and especially if they were to invite discussion, they might, at a very small sacrifice of time or trouble, do much to invigorate a class of Institutions which have too generally fallen into a state of comparative somnolency and uselessness, but which might easily be rendered valuable means of popular instruction.

Home Correspondence.

LIQUID MANURE.

Sir,—I have observed in the *Journal of the Society of Arts*, of the 19th instant, an account of a lecture given by a Mr. Wilkins, at the London Tavern, furnished by Mr. H. P. Stephenson, of 37, Charing-cross.

Whatever merit may attach to the method of such cultivation therein described, I beg most unequivocally to state the plan or system did not originate with Mr. Wilkins, but with myself (several years past). In confirmation of this statement, I now enclose a pamphlet, published by me in 1850, upwards of six thousand of which have been distributed. If you refer to page 10, you will see my description of the culture of celery, with a woodcut of the plan (this description is appended). I acquainted Mr. Wilkins of the circumstance more than twelve months past, and gave him my card at the Cattle Show in Baker-street, where he was expatiating to many farmers on the subject; he called me aside, and said he would write me on the matter, but I have never heard more of him. I think it but right in self defence that the public should know to whom the merit is due, and as such trust to your sense of justice to insert this in one of your early numbers.

I do not hesitate to state that all root crops and most cereals can be grown finer by the means in question than by any other, on light friable earth, but not on retentive or clayey soil. From experiments I have made, I am warranted in stating, that the fresher and longer (in reason) dung is the better for stiff soil, as the silica of the straw unites with the alumina and makes a better fertilizer than very rotten dung or liquid manure.

In fact I go further, and state that straw cut in lengths of about four inches, and well soaked in liquid manure, (urine from stables or feeding stalls) is the best possible manure for stiff soils; it keeps the soil open to receive all moisture, and likewise carries of all excess. There is no one method alone will answer for every soil; it would be much the same as saying a particular pill will cure all complaints.

I am of opinion that there is abundance of (waste) land which lets for 2s. 6d. per acre in many counties, on which I could grow the finest wheat, barley, turnips, in short, every crop, that would be worth six pounds per acre, with an outlay of ninety to one hundred pounds per acre; it would be a permanent improvement, and give astonishing results. By the plan in question I have raised celery 12lbs. per head; strawberries, seven of which weighed 17 ounces; and asparagus which filled tubes an inch in diameter; these were exhibited in private to editors and sub-editors of various newspapers five years since; therefore, it can be no secret.

I am, sir, yours truly,
JOHN ROBERTS, F.S.A.

Upnor lodge, near Rochester, Jan. 22, 1855.

"On the Improved Culture of Asparagus, with Roberts's Asparagus Tubes.—The secret consists in a rapid growth, and from its situation in a natural state, it is obvious that it should have a light soil, which offers little resistance to the emission of its roots, or the protrusion of its stems: the soil should be capable of receiving and parting with water readily, consequently, when asparagus beds are made, perfect drainage is the first step for consideration; that being ensured, dig out the earth two feet deep, four feet wide, and the length required,—place strong bushes at the bottom, one foot deep, then cover them with good old well-rotted stable dung, fully six inches deep or thick; upon the dung put two pounds of salt to every square yard, then some light friable earth, mixed with river sand, in the proportion of four parts earth one part of sand; these must be well sifted through a sieve, the holes of which must not be larger than ⅜ of an inch square, which will remove every stone of importance; when enough of this mixture is sifted, fill up the remaining six inches of the trench, and the bed is ready for the plants; mark out the spaces, allowing a square foot to each plant, open and spread out the roots each way. When all the plants are put in their respective places, sift over them four inches of the same mixture, soil and sand, as you put under them; the bed will then be finished. Late in March or early in April is the best time for the operation, if the weather is fine and dry, as it should be when the beds are made. Those who require the asparagus very large should plant in single rows, three feet apart, the plants two feet apart. There will be no further care required except to water in dry weather, and keep the beds free from weeds. At the end of October or early in November, when the stems are all ripe and withered, cut them off close to the soil, and put on the bed well-decayed leaves or well-rotted dung, to the depth of two inches, and upon that one pound of salt to each square yard, sift a little soil and sand over it, about an inch deep (more will not be necessary); nothing more need be done till early in March following, when the surface of the bed should be slightly forked over, but not deep, say three inches only; put on one pound of salt to each square yard, and water very frequently with liquid manure till the end of April, but on no account cut any of the asparagus that season, however fine it may appear. In October attend to give the same treatment as last, also again in March. This being the third season, you may cut a few of the finest heads only, but after this season, if the treatment is continued, as before stated, every autumn and spring, you may have fine asparagus for twenty years, of the best flavour, and without the silly plan of earthing up the beds three feet high, as gardeners generally do, merely to show a blanched end, as hard as wood, only about two inches of which can be eaten. All that labour may be saved by placing asparagus tubes over it as soon as it appears above the ground. These will preserve it tender and good, and every particle may be eaten with relish; so that, in fact, your beds may be said to produce three times as much serviceable food as those now generally in use. Those who have asparagus beds made on the old system, will find it much to their advantage to rake off three parts of the soil now heaped on them, when the stems are ripe, and treat them precisely as directed on the plan now set forth, and in spring, as soon as the heads appear above ground, place asparagus tubes over them,—the improvement will be such that I engage to say the old plan will never be tried again by the same person."

THE COST OF PEAT CHARCOAL.

Sir,—In reply to a letter published in the Journal of the 26th instant, from Mr. Mark Fothergill, I beg to say that I stated distinctly that the cost of my patent peat charcoal would not exceed 10s. to 12s. per ton at the place of manufacture on the bog.

In reference to the statement of this gentleman, of the cost of manufacturing peat charcoal, the item of 6s. 9d. for draining and value of bog, is not applicable to my case, as I am offered thousands of acres of the finest bog at a mere nominal rent, and well *drained*, situate in the best localities for transit, either by rail or water conveyance; again, we neither pile, dry, burn, nor grind the peat previous to saturation with sulphuric acid; thus these items of cost,

amounting to £1 18s. 6d. by the retort method, are entirely avoided. Instead of which we have the following charges, viz.:—

Cutting bog, estimated dry, 1½ tons; carriage from bog to factory per tram, and placing in vats; sulphuric acid to saturate dry peat for fuel, half a ton; labour placing the bog in drying chambers and drawing the charge; over-looker, &c., &c.; wear and tear of plant £0 10 0

Produce one ton of charcoal suitable for locomotive engines, smelting iron ore, and the general purposes of fuel. In case the bog is too tender, or not sufficiently compact, there will be a further charge for pressing and shaping (per machine), of about 9d. to 1s. per ton; and for grinding it to a size suitable for sanitary purposes and manure, another shilling must be added; in this way the 10s. to 12s. per ton is made up.

By the old process four tons of dried peat have to be burned in retorts or otherwise to produce one ton of charcoal, whilst by the patented process a sufficient quantity of peat to produce 1½ tons of dried peat will produce 1 ton of charcoal of superior quality, inasmuch as that produced by the old method contains in one ton the impurities of 4 tons of peat, whilst by the new process, one ton contains the impurities of only 1½ tons peat, the difference being in the ratio of 16 parts of impurities of the old to 6 in that produced by the new process.

In endeavouring to take a broad and comprehensive view of this great national question, I have arrived at the conclusion, that wherever a railway traverses a bog, there will the charcoal be made and consumed; wherever rich iron ore of a certain quality be found contiguous to bog, there the charcoal will be manufactured and the ore smelted. Bogs exist in many of the agricultural districts, and in the vicinity of large cities and towns there will the charcoal be made, and consumers supplied direct for sanitary and agricultural purposes, without the intervention of expensive agencies, warehousing, freights, carriage, &c. I think it fair to say in conclusion, I have based all my estimates of cost, calculations, &c., on large transactions. Apologising for occupying so much space on this occasion,

I remain,
Thine faithfully,
WILLIAM LONGMAID.

65, Beaumont-square,
London, Jan. 31, 1855.

MEETINGS FOR THE ENSUING WEEK.

Mon. Royal Inst. 2. General Monthly Meeting.
Architects, 8. Messrs. C. C. Nelson and M. D. Wyatt, "Some Notice of a Work entitled 'Early Christian Monuments of Constantinople, from the Fifth to the Twelfth Century,' by W. Salzenberg."
Chemical, 8.
Entomological, 8.

Tues. Horticultural, 2.
Royal Inst., 3. Professor Tyndall, "On Magnetism."
Civil Engineers, 8. Mr. J. Leslie, "Observations on the Flow of Water through Pipes and Orifices."
Linnæan, 8.
Pathological, 8.

Wed. Society of Arts, 8. Mr. Thomas Dickins, "The Commercial Consideration of the Silk-Worm, and its Products."
Pharmaceutical, 8½.

Thurs. Royal Inst., 3. Mr. Donne, "On English Literature."
Antiquaries, 8.
Royal, 8½.

Fri. Astronomical, 8. Anniversary.
Philological, 8.
Royal Inst., 8½. Prof. Owen, "On the Orangs and Chimpanzees, and their Structural Relations to Man."

Sat. Royal Inst, 3. Dr. Gladstone, "On the Principles of Chemistry."
Royal Botanic, 3¾.
Medical, 8.

PARLIAMENTARY REPORTS.

SESSIONAL PRINTED PAPERS,
Delivered on 25th January, 1855.

Par. No.
18. The Crimea—Copy of Letter from General Canrobert.
6. Bills—Jurors and Juries (Ireland) (No. 2.)
12. Bills—Fairs and Markets (Ireland)
Steam Ship, "Forerunner"—Report.

Delivered on 26th January, 1855.

15. Local Boards of Health—Return.
13. Bill—Nuisances Removal and Diseases Prevention Acts, Consolidation and Amendment.
Post-office Arrangements with France—Convention.

Delivered on 27th and 29th January, 1855.

23. Coal (Heraclea)—Return.)
26. Naval Receipt and Expenditure—Account.
27. Deficiency Bills, &c.—Statements.
28. Public Income and Expenditure (Balance Sheet), Account.
24. Transports—Return
23. Coal (Heraclea), A Corrected Plan.
2. Bills—Jurors and Juries (Ireland).

Session 1854.

463. Metropolitan Parks, &c.—Return.
525. (1.) National Education in Ireland—Index to Lord's Report.

Delivered on 30th January, 1855.

19. Population, &c. (Scotland) Abstract Return.
31. Court of Session, (Scotland—Return.

446. Savings Bank—Return.

PATENT LAW AMENDMENT ACT, 1852.

APPLICATIONS FOR PATENTS AND PROTECTION ALLOWED.

[*From Gazette, Jan. 26th*, 1855.]

Dated 14th October, 1854.

2202. L. Monzani, Greyhound-place, Old Kent-road, Bedsteads.

Dated 14th November, 1854.

2414. G. Bodley, Everhard-street East—Revolving cannon.

Dated 19th December, 1854.

2671. W. P. Dreaper, Liverpool—Pianofortes.

Dated 1st January, 1855.

3. J. Seguin, Paris—Motive power.
5. S. Giles, Caledonian-road—Ratchet brace.

Dated 2nd January, 1855.

7. A. Roullion, Paris—Soap.
9. J. Arnold, Tamworth—Ornamenting bricks.
11. G. Peacock, Gracechurch-street—Propellers.

Dated 3rd January, 1855.

13. F. G. C. Dehaynin, Paris—Purification of hydrogen gas.
15. J. Lippurann, Paris—Splitting skins of animals.
17. S. A. Goddard, Birmingham—Fire-arm.
19. J. Gaskell, Manchester—Mortar and cement.
21. A. S. Stocker and S. Darling, 11, Poultry—Bottles, pots, jars, tubes, &c.
23. J. Venables and A. Mann, Burslem—Figures in plastic materials.
25. G. W. Muir, Glasgow—Warming and ventilating.

Dated 5th January, 1855.

27. L. J. Martin, Paris—Colours for printing and dyeing.
29. W. H. Bulmer and W. Bailey, Halifax—Combing machinery.
31. R. Ashworth and S. Stott, Rochdale—Spinning machinery.
33. F. Prince, 3, South-parade, Chelsea—Cartridges for fire-arms.

Dated 6th January, 1855.

35. J. H. Johnson, 47, Lincoln's-inn-fields—Agricultural machinery and motive power. (A communication.)
37. J. B. E. Ruttre, Paris—Treatment of woollen and vegetable rags.
39. J. Scott, Sunderland—Anchors.
41. C. J. Edwards, jun., Great Sutton-street, Clerkenwell, and F. Frasi, Tavistock-terrace, Holloway—Axle bearings.

Dated 8th January, 1855.

43. J. Huggins, Birmingham—Lint.
45. R. McCall, Pallas-Kenry, Limerick—Iron and steel.
47. W. and J. Hay, Glasgow—Motive-power engines.
49. J. Bury, Manchester—Embossing Orleans cloth.

Dated 9th January, 1855.

51. E. Hayes, Stony Stratford—Feeding thrashing machines.
53. J. Offord, Wells-street, Oxford-street—Carriages.
55. P. E. Thomas, Paris—Obtaining wool from tissues of wool mixed with other fibres.
57. Commander H. J. Hall, R.N., Charlton, and A. Dalgety and E. Ledger, Deptford—Propelling ships.
59. W. Major, Copenhagen—Screw propellers.

Dated 10th January, 1855.

61. T. Wilson, Birmingham—Bands for fire-arms.
62. B. Predaval, 106, Great Russell-street—Paper pulp.
63. W. T. Henley, St. John-street-road—Steam boilers.
64. E. Booth, Gorton—Dressing, starching, and finishing textile fabrics.
65. W. C. Fuller, Bucklersbury—India-rubber springs.
66. H. Bessemer, Queen-street-place—Iron and steel.
68. L. P. Lehugeur and M. Uttinger, St. Denis, near Paris—Machinery for printing fabrics.

Dated 11th January, 1855.

69. J. Gedge, 4, Wellington-street South, Strand—Metallic flooring. (A communication.)
70. J. L. Hervé, Paris—Preserving meat and fish.
71. J. Norton, Dublin—Draining land.
72. A. Robertson, Upper Holloway—Packages for dry goods.
73. E. Hall, Dartford—Gunpowder
74. R. Oxland, Plymouth—Animal charcoal.
75. E. Townsend, Massachusetts—Stitching machinery. (A communication.)
76. J. Wood, 30, Barbican—Lettering and ornamenting glass.
77. W. L. Thomas, Anderton, Devon—Projectiles and gun wads.
78. S. W. Davids, Carnarvon—Elongating chandeliers and gaseliers.

Dated 12th January, 1855.

81. W. Hunt, Tipton—Iron.
82. J. R. Hodgson, Sunderland—Anchors.
83. F. V. Guyard, Gravelines—Electro-telegraphic communications.)
84. E. Miles, Stoke Hammond, Bucks—Coupling joint for tubing.
85. C. Turner, Burnley—Power looms.
86. J. Harrison and J. Oddie, Blackburn—Preparing yarns for weaving.
87. F. Preston, Manchester—Ordnance and projectiles.
88. W. Barningham, Salford—Connecting rails of railways.
89. A. Seithen, Coblenz, and J. H. Lichtenstein, Berlin—Cork machinery.
90. R. A. Brooman, 166, Fleet-street—De-vulcanizing India rubber (A communication.)
91. P. N. Gadol, Bermondsey—Tanning.

Dated 13th January, 1855.

93. W. H. Nevill, Llanelly—Reverberatory furnaces.
94. J. Graham, Hartshead Print Works, near Stalybridge—Fixing colours in yarns.
95. G. Warnecke, Frankfort-on-the-Maine—Preserving vegetables and fruits.
96. J. Claudot, Paris—Stucco.
97. M. D. Hollins, Stoke-upon-Trent—Slip kilns for drying clay.
98. E. L. Hayward, Blackfriars-road—Kitchen ranges.
99. J. C. Pearce, Bowling Iron Works—Iron.
100. J. E. Outridge, Constantinople—Transmitting motive-power.
101. J. Greenwood, Irwell-springs, near Bacup—Finishing textile fabrics.

Dated 15th January, 1855.

102. F. Burke, Montserrat, West Indies—Obtaining fibres from plantain, banana, aloe, penguin, &c.
103. W. T. Frost, Shottle, near Belper—Machinery for cleaning knives.
104. H. M. Ommaney, Chester—Projectiles.
105. J. P. Lark, Nine-elms-lane—Consumption of smoke.
106. G. Riley, 12, Portland-place North, Clapham-road—False bottom for mash tubs.
107. E. Haynes, jun., Bromley—Smoke-consuming furnace.

Dated 16th January, 1855.

108. M. T. Stefani, Paris—Fire-arms.
110. H. Adkins, Edgbaston, Birmingham—Bleaching oily and fatty bodies.
111. J. Yeoman, Walworth—Self-feeding furnaces.
112. G. Jackson, Manchester—Tents.
113. J. Simkin, Bolton-le-Moors—Rifles and fire-arms.
114. J. L. Norton, Holland-street, Blackfriars—Recovering wool from fabrics.
115. J. Saunders, St. John's-wood—Axles and shafting.
117. R. J. Mar'yon, 37, York-road, Lambeth—Steam engines.

Dated 17th January, 1855.

118. G. W. Garrood, Burnham—Machinery for raising or lowering weights.
119. S. Lomas, Manchester—Silk machinery.
120. J. Horton, Birmingham—Storing gunpowder.
121. A. Quertinier, Charleroi—Glass furnaces.
122. A. Colles, Millmount, Kilkenny—Sawing marble. (A communication.)
123. Capt. D. Davidson, Meiklewood-by-Stirling, N.B.—Pointing ordnance and restoring the aim.
124. J. Webster, Collingham—Motive power.
125. J. Higgins and T. S. Whitworth, Salford—Moulding for casting shot, shells, &c.
127. E. Hall, Salford—Wire ribbon.
128. L. Flower, 37, Great Russell-street, and G. A. Dixon, Stratford—Sifting and cleansing machinery.

INVENTION WITH COMPLETE SPECIFICATION FILED.

154. C. Van den Bergh, Lacken, by Brussels—Rotatory steam-engines.—20th January, 1855.

WEEKLY LIST OF PATENTS SEALED.

Sealed January 26th, 1855.

1659. Henry Wickens, 4, Tokenhouse-yard—Improvements in the means of giving signals on railways and for other purposes.
1665. Richard Johnson, Manchester—Improvements in coating and insulating wire.
1679. Auguste Edouard Loradoux Bellford, 16, Castle-street, Holborn—Improved method of engraving.
1689. Edward Gillman, Twickenham—Improvements in the manufacture of paper, papier maché, and other similar articles from certain vegetable substances.
1724. Edouard Alexandre, Paris—Improvements in concertinas.
1738. Antoine Corvi, Paris—Improvements in musical instruments.
1761. Thomas George Taylor, King's Arms Yard, City—The use or application of the stalk of the hop plant in the manufacture of paper, pasteboard and millboard, cordage, rope, and textile fabrics.
1768. Henri Louis Edmond Désiré Hennebutte, Esquermes-lez-Lille (Nord), France—Improvements in the manufacture of varnishes.
1777. John Norton, Cork—Improvements in bolts and projectiles for fire-arms.
1785. Samuel Frankham, Greenland-place—Improved means of consuming smoke and economizing fuel in furnaces.
1788. William Burgess, Newgate-street—Improvement in or addition to reaping and mowing machines.
1789. William Siddons, Birmingham—Improvements in locks for guns and other fire-arms
1796. John Turner Wright, and Edwin Payton Wright, Birmingham—Improvements in the manufacture of ropes, cords, lines, and twines.
1798. Charles Blake, Saint Leonards—Improvement in or addition to doors and door and window frames.
1863. Henry Bessemer, Baxter-house, Old Saint Pancras-road—Improvements in guns for throwing projectiles for naval and military purposes.
1882. John Kirkham, Tonbridge-place, New-road, and Thomas Nesham Kirkham, Edith-grove, West Brompton—Improvements in the process of manufacturing and purifying gases for lighting and heating, and in apparatus to be employed therein.
1956. James Burns, Manchester—Improvements in ventilating ships.
2169. John Kershaw, Brixton—Improvements in the manufacture of wrought-iron railway wheels.
2196. Anthony Bernhard Baron Von Rathen, Wells-street—Improvements in bakers' and confectioners' ovens, and in furnaces or fireplaces connected therewith, parts of which improvements are applicable also to other ovens, furnaces, and stoves.
2311. William Reid, University-street—Improvements in the manufacture of galvanic batteries.
2416. David Davis, Wigmore-street, Cavendish-square—Improvement in roller blinds.
2458. Fisk Russell, Massachusetts, U.S.—Machine for mowing grass.
2459. William Beasley, Smethwick—Improvements in the manufacture of gun-barrels.
2481. Samuel Alfred Carpenter, Birmingham—Improved buckle or substitute for a buckle.
2486. Cyprien Marie Tessié du Motay, Paris—Improvement in treating soap to obtain back the fatty or oily matters in their original state,
2489. Henry Bessemer, Old Saint Pancras-road—Improvements in projectiles and in guns or ordnance used for discharging the same.
2490. Thomas De la Rue, Bunhill-row—Improvement in the manufacture of compositions suitable for printing rollers, printing ink, and flexible moulds.
2496. Joseph Gillott, jun., and Henry Gillott, Birmingham—Improvements in metallic pens, and new or improved machinery for the manufacture of metallic pens.
2510. George Gowland, South Castle-street, Liverpool—Improvements in the mariner's compass.
2512. Sydney Smith, Hyson Green Works, near Nottingham—Improvement in gauges for ascertaining the pressure of steam and other fluids.
2518. Edwin Pettitt, Manchester—Improvements in machinery for drawing cotton and other yarns.
2521. John Sands, 11, Austin Friars—Improvements in the mariner's compass. (A communication.)
2542. Joseph Maudslay, Westminster-road—Improvement in ordnance.

Sealed January 30th, 1855.

1713. Commander Alfred Kortright, R.N., James-street, Adelphi—Improvements in marine and surveying compasses.
1745. William Armand Gilbee, 4, South-street, Finsbury—Improvements in hydraulic machines.
1793. William Johnson, 47, Lincoln's Inn Fields—Improvements in furnaces, and in the consumption or prevention of smoke, (A communication.)
1795. Charles Cowper, 20, Southampton-buildings, Chancery-lane,—Improvements in the felting of hats, and in machinery for that purpose.
1815. Frederick Crace Calvert, Manchester—Improvements in the treatment of heating, puddling, and refinery iron slags or cinders.
1879. Thomas Carr, Liverpool—Improvements in steering apparatus.
2539. Auguste Edouard Loradoux Bellford, 16, Castle-street, Holborn—Improvements in apparatus for the manufacture of combustible gas.